REPORT RESUMES

ED 003 560 56

THE EFFECT ON INSTRUCTION OF THE COMPLEMENTARY USE OF AUDIOVISUAL MEDIA WITH MODIFIED PATTERNS IN THE USE OF THE TEACHING STAFF.

BY- FRITZ, JOHN O.

CHICAGO UNIV., GRADUATE SCHOOL OF EDUCATION

REPORT NUMBER NDEA-VIIA-399 PUB DATE SEP 63

GRANT OEG-7-11-068

EDRS PRICE MF-$0.27 HC-$7.56 189P.

DESCRIPTORS- *AUDIOVISUAL INSTRUCTION, *PHYSICS INSTRUCTION, TEACHING TECHNIQUES, COMPARATIVE ANALYSIS, HIGH SCHOOLS, LEARNING PROCESSES, *MEDIA RESEARCH, *INSTRUCTIONAL INNOVATION, CHICAGO, ILLINOIS, PHYSICAL SCIENCE STUDY COMMITTEE

TWO HIGH SCHOOL PHYSICS CLASSES WERE CHOSEN TO BE EXPERIMENTAL GROUPS IN A STUDY OF THE EFFECTIVENESS OF AUDIOVISUAL MEDIA USED IN A COMPLEMENTARY (RATHER THAN SUPPLEMENTARY) ROLE IN THE INSTRUCTIONAL PROCESS. FOUR CLASSES TAUGHT BY TWO TEACHERS COMPRISED THE CONTROL GROUP. THE EXPERIMENTAL DESIGN WAS COMPLICATED IN THAT THE GROUPS WERE STRATIFIED ALONG FOUR DIMENSIONS, NAMELY, COMPLEMENTARY ROLE OF AUDIOVISUAL MEDIA, TEACHER COLLABORATION, VARIABLE CLASS STRUCTURE, AND FREE ACCESS TO THE SCHOOLS' RESOURCES. THE INSTRUCTIONAL MATERIALS CONSISTED OF THE ORGANIZED COLLECTION OF ACTIVITIES DESIGNED BY THE PHYSICAL SCIENCE STUDY COMMITTEE. MORE CHANGES WERE OBSERVED IN THE TEACHERS THAN IN THE STUDENTS IN THIS EXPERIMENT. (JK)

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education
This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

THE EFFECT ON INSTRUCTION OF THE COMPLEMENTARY USE OF AUDIO-VISUAL MEDIA WITH MODIFIED PATTERNS IN THE USE OF THE TEACHING STAFF

John O. Fritz

September 1963

Title VII Project Number 399
National Defense Education Act of 1958
Grant Number 7-11-068

ED003560

ACKNOWLEDGMENTS

An experimental program of the scope represented in this project is the product of the combined efforts of many individuals, groups, and institutions. Maine Township High School East of Park Ridge, Illinois and Niles Township High School East of Skokie, Illinois made generous provision of necessary facilities and resources to implement the program. The cooperating teachers, Mr. Ronald Teller, Mr. Andrew Ahlgren, Mr. Carl Burgener, and Mr. Ellerth Overboe, engaged themselves with a seriousness of purpose befitting their professional position.

Many colleagues in the Department and Graduate School of Education of the University of Chicago provided willing assistance when they were approached for advice and consultation. Particular recognition is made of the contribution by Dr. John Ginther in the selection and application of evaluation procedures. The skill and talents of Miss Marge Gonce in audio-visual preparation are evidenced in the hundreds of slide-tape series and overhead transparencies that she prepared for the project. Miss Rena Matusen, able and resourceful, dealt efficiently with the multitude of unavoidable details that emerge in the wake of any research program.

This acknowledgment would not be complete without recognition of the important contributions by the Graduate School of Education, and particularly that of Dr. Francis S. Chase, its Dean, who combines a pronounced commitment to educational research with an unusual determination to support and encourage the researcher engaged in its pursuit.

J. O. F.
September, 1963

TABLE OF CONTENTS

Chapter	Title	Page
I	Problem and Purpose	1-16
II	Methodology and Research Procedures	17-40
III	Results	41-101
IV	Summary Review, Conclusions and Discussion, and Further Research	102-116

Appendices	Title	Page
A	Pre-Test (achievement)	A1-A7
B	Post-Test (achievement)	B1-B18
C	Q-Sort	C1-C9
D	Student Opinion Survey	D1-D8
E	Attitude Opinionnaire	E1-E6
F	Student Information Card	F1
G	Teacher and Teacher Assistant Tasks, Logs, Codes, Schedules	G1-G3
H	Physical Science Study Committee Films Used in Project and Slide-Tape Series Prepared for Project	H1-H3

Bibliography

LIST OF TABLES

Table No.	Contents	Page No.
1	Mean Differences for Scores on Independent Variables - School A	42
2	Mean Differences in Gain Scores - School A	44
3	Mean Differences in Pre and Post Attitude Scores	45
4	Significance of the Difference in Mean Scores	46
5	Significance of Differences in Pre and Post Mean Subscores - Scientist	47
6	Mean Differences on Pre and Post Subscores - Science-Society	48
7	Mean Differences in Course Assessment in January (I) and June (II) - Student Opinion Survey	49
8	Significance of the Difference in Mean Scores -- SOS II	50
9	Mean Differences in "You" Sorts I, II, III	51
10	Mean Differences in "Inquiry" Subscores - "You" Sort I, II, III	52
11	Mean Differences in Scores of the Subjects' "Teacher" Sorts - I, II, III	53
12	Significance of the Mean Differences in Subjects' "Teacher I" Sort in June	54
13	Mean Difference - "Did" Sorts - June - School A	57
14	Teacher Assistant Log Record - School A - Number of Times Operations Recorded - March 7 - June 15	58
15	Deployable Time Available through Complementary Use of Media - March 7 to June 15, 1962	59

Table No.	Contents	Page No.
16	Group Means on Independent Variables	62
17	Mean Gain Scores - Groups C, EI, EII	64
18	Mean Differences - Gain Scores C, EI, EII	64
19	Significance of Difference - Mean Gain Scores - C vs. EI	65
20	Significance of Difference - Mean Gain Subscores - (LMP) - C vs. EI	66
21	Significance of Difference - Mean Gain Scores - C vs. EII	66
22	Mean Scores - Pre and Post Attitude Scores (I and II) - C, EI, EII	67
23	Significance of Mean Difference - Science Attitude I and II	68
24	Significance of Mean Differences - Corrected for Differences in Pre Math Grade	69
25	Significance of Mean Differences - Pre and Post-Science Attitude Subscores	70
26	Mean Scores - SOS January (I) and June (II) - C, EI, EII	72
27	Significance of Mean Differences - SOS I and II	72
28	Mean Scores - "You" Sorts - September (I), January (II), and June (III)	74
29	Significance of Mean Differences - "You" Sorts I, II, III	75
30	Significance of Mean Differences - "You" Sort Subscores - I, II, III	76
31	Mean Scores - "Teacher" Sorts - I, II, III	78

Table No.	Contents	Page No.
32	Significance of Differences - "Teacher" Sorts I, II, III	80
33	Significance of Differences - "Teacher" Sort Subscores - I, II, III	81
34	Mean Scores - "Did" Sorts - June	83
35	Significance of Differences - "Did" Sorts - June	84
36	Significance of Differences - "Did" Sort - III - Subscores	85
37	Cumulative "Free Access" Record - EII (N=40)	86
38	Significance of Differences - Achievement Tests - HFA vs LFA (EII)	88
39	Mean Subscores of HFA and LFA for Inquiry Tasks - "T1 and T2" Sorts - June	91
40	Deployable Teacher Time and Origin (EI and EII)	93
41	Logged Use of Deployable Teacher Time (T1 + T2)	94
42	Variable Class Structure - (EI and EII)	96
43	Operations Logged by Teacher Assistant in EI and EII	98
44	Q-Sorts - Y>T vs Y<T - September (C and EII)	100

CHAPTER I

PROBLEM AND PURPOSE

Problem

American education today is receiving critical examination and appraisal from educators and laymen alike. Concern is widespread over the extent to which the schools of the nation are cultivating those competencies in the student population that are necessary for effective behavior in the adult world. On the operational level, a basic task confronting educators and teachers is the identification and implementation of means to increase the effectiveness of the teaching-learning process in order that (1) students have learning experiences that result in the acquisition of a larger fund of significant and reliable knowledge, better comprehended and more intelligently and resourcefully applied; and (2) students emerge with improved competencies in critical inquiry and enhanced determination to pursue and sustain self-initiated study. As an expression of this overriding concern, educators and researchers have explored various ways in which the use of educational technology and communications devices can serve to achieve the objective of improved learning in our schools.

Until recently, audio-visual materials were regarded as "aids" to the teacher. Visual media, such as motion pictures, could help the teacher in unique ways. They magnified inconspicuous details in a series of ongoing events. They made microscopic processes perceptible to the viewer; by time-lapse photography children could observe the growth of plant and bacterial life. Motion pictures and slides overcame the boundaries of time in history and space in geography. They dramatized and portrayed the best in literature and the arts in full color. In short, audio-visual media brought the world into the classroom to promote the intellectual and emotional growth of youngsters. In accord with this concept, film producers provided teachers with motion pictures designed to prove useful in a variety of instructional situations only if they were carefully evaluated, carefully selected, and carefully used. Teachers were warned that films could promote learning only if they were shown at the right time, in the right way, under adequate viewing conditions, with the right group, and for the right purposes. The teacher remained in control as he worked to create a given learning environment.

In the face of the need for improved instruction, research in the area of audio-visual communication---particularly the studies that have been conducted since World War II---has generally provided disappointing evidence and little assistance in suggesting improved applications of these media in the instructional process. (2, 8, 14, 16, 17, 22, 23) These studies, attempting largely to measure empirically increments of learning gained through the use of audio-visual media, have repeatedly revealed no significant differences between control and experimental groups. The additional use of audio-visual media in teaching has led apparently to no measurable gains in learning. This finding is particularly evident in more recent studies that are larger in scope, more rigorous in experimental design, and are more concerned with the preparation and validation of testing instruments. (2, 11, 23) This evidence is disconcerting from a research standpoint but, more important, these findings serve to discourage school administrators, teachers, and educators in professional education from exploring further the use of audio-visual media in instruction. Reactions to the emerging technology are apparently tending in diametrically opposite directions. In some quarters there has been disenchantment with the newer audio-visual media and this disenchantment has been followed by a return to conventional teaching practices. In other quarters there has been zealous exploitation of motion pictures and television in programs of instruction that encompass ever greater numbers of students.

Such lack of definitiveness in research results may be due partly to inappropriate research methodology. However, increased research rigor in study designs and methods does not promise to bring forth more helpful results. It is suggested that the factors underlying this indeterminism in available research evidence involve the conceptual role of the audio-visual media in instruction and, concomitantly, the necessity to re-examine and redefine the role of other agents, including the teachers, in the structuring of learning environments.

With the advent of television as an educational tool, these media have gradually assumed a role that departs sharply from the traditional concept of supplementary aid. Film and television are acquiring value because they can store instruction and extend the reach of an instructor. Transmitted by motion picture, kinescope, video-tape, or live television, regular systematic instruction can now be provided to larger and larger groups of students. Past attempts at improving instruction through the use of audio-visual devices have suffered by the deficiencies inherent in the "supplementary" concept of the role of the media in instruction. The present project challenges this conceptual role as inadequate in that it prevents the use of the media from exercising optimal impact in the teaching-learning process. Unless the conceived role or function of the technological devices in education is critically reappraised and modified, further attempts to enhance the effectiveness of teaching methods through these communication devices will likely be confronted by the same ambiguous and indefinitive results.

Now that these media can store and disseminate subject matter, they are performing teaching functions that previously had been the exclusive domain of the teacher. They can illustrate, discuss, and analyse concepts and generalizations and systematically prescribe areas for continued student inquiry. When teaching draws on the unique characteristics of film or television, it may occasionally even surpass in effectiveness prevailing instruction in a school program. It therefore seems inappropriate to categorize these materials under the rubric of supplementary aids. They are better regarded as complementing the instructional resources of a school program. In doing so, however, they make it necessary to reformulate the conventional role of the teacher in the classroom.

Purpose

This study addresses itself to the continuing question, "In what ways and to what extent may the use of the available communications media such as television, slides, film, and tape recordings improve significantly the teaching-learning process in the schools?" It is no longer a question as to whether films can teach, but whether schools, through the use of audio-visual devices, can realize substantial learning increments in the same or less instructional time, intensified student interest in pursuing inquiry, and increased self-initiated study on the part of the students. The expectation is that the question may be answered in the affirmative given certain conditions under which the media are introduced and used in instruction.

In the description and definition of the variables that are introduced in the study, the assumption is made that the operation of any one component is dependent, more or less, upon the presence and operation of other components to which the former might be related. Simply, recognition is given to the fact that the use of audio-visual media in instruction must be conceived in terms of a man-machine system of inter-related and interdependent component parts and their corresponding operations. The manipulation of any one of them must be accomplished with due regard for and, in some cases, the simultaneous manipulation of other component parts in order to maintain the optimum productivity of the whole system.

Specifically, the purpose of the project will be to introduce such a system as a totality and effect variations of this system in an experimental design which would permit comparisons between the different variants so introduced. The component parts of the system and their operation are represented by the following four dimensions:

(1) The complementary (rather than supplementary) use of the available technological devices and communications media;
(2) The collaborative involvement of teaching staff (two teachers) and their participation in roles of a higher professional order;
(3) Variable class structure accomplished in the service of existent and future demands and purposes in instruction;
(4) Free access for individual students to the audio-visual as well as printed resource materials to further independent study.

This system and its variants were introduced in the course of introductory physics on the high school level. Physics was selected for three reasons: (a) a large number of audio-visual materials have been prepared and are available in this subject area; (b) a considerable amount of research has already been conducted both in the application of audio-visual media in teaching science as well as into other problems of teaching method and curriculum; (18) and (c) the subject matter itself is highly visualizable and therefore facilitates the optimum use of audio-visual media.

The Nature of the Components

(1) The complementary role of audio-visual media.

It is the contention of this study that the concept of supplementary role of audio-visual media in instruction is largely manifest in past audio-visual research studies and prevails in teaching practices today. In this conception, the materials are subsidiary and subordinate to the efforts of the teacher. This is a corollary to the premise implicit in current educational practice---teaching can occur only through the vehicle of the person of the teacher. Hence, instructional films are planned and produced with the acceptance of traditional and prevailing assumptions in education dealing with the size of classes, the function or role of the teacher, the organization of teaching staff, as well as teaching practices in the classroom. Such instructional films necessitate careful selection and proper introduction as well as follow-up activity, all engineered directly by the person of the teacher in the teaching situation. To the teacher these media are merely additional teaching resources which he may elect to use to assist him in his direct teaching efforts. What the teacher does and how he functions remains largely unchanged by the use of such film material. Films produced and used to fit this prevailing role of instructional media, however, do not allow full play to the teaching potential of the communications devices. As in industry, the introduction of the machine will fail to increase the productivity of the educational process if no significant changes are made in the operations performed by the human agents to exploit the potentialities of the machine.

The supplementary use of audio-visual media has led to two significant consequences: (1) Excessive redundancy in the teaching process that has two sources: (a) a redundancy that lies within the film itself. A ten minute film, for instance, may contain six or seven minutes of footage which for some students in the audience did not provide any new experiences; (b) techniques of teacher use serve likewise to increase redundancy in teaching by resulting in unnecessary repetition of content in the motion picture. Recommended practice has the teacher introduce the film by emphasizing points to attend to, show the film, and then review the material covered in the film by stressing once more its main ideas.

(2) A second consequence takes the form of "compensatory effort" on the part of students participating in research projects. An examination of studies, particularly the Wisconsin Study (23) and the studies at Pennsylvania State (2, 7), suggests that differential student effort in the experimental and control situations may be obscuring differences between the experimental and control teaching methods. This factor can be called "compensatory effort" on the part of both groups of students. If it can be assumed that students generally aspire to a given level of accomplishment and strive to acquire a certain degree of felt competence in comprehending the subject matter, then it is reasonable to expect that varying student effort in the course may serve differentially to offset the relative impact of given experimental variables in teaching. It may be that the students who receive the "experimental" course content are better able to comprehend and grasp the material under discussion in the class. As a result, they feel relatively less need to exert themselves in studying on their own in that they are able to achieve now more easily (with less time and effort) a given degree of self-confidence in "knowing" the subject matter. Students receiving the conventional course treatment in all likelihood study as they did in the past until they likewise realize a comparable degree of confidence which enables them to achieve their level of aspiration, usually a specific course grade. The Wisconsin project provides partial support for the hypothesis of compensatory effort in such situations in that students receiving the film course reported that they did "less textbook reading, less writing-up of assignments, less outside-of-class studying, more note-taking, and more paying attention in class than did the students in the control schools." (23) Such compensatory effort in both experimental and control groups may have served to obscure any differences between the effectiveness of the two methods of instruction. Results evidently show no

apparent superiority of one method over another.

Compensatory effort is encouraged and facilitated in the supplementary use of communications media in that the content of most audio-visual materials, particularly in the sciences, emphasizes the description and elucidation of factual material in the form of concepts and generalizations. (12) Furthermore, the manner in which the material is used by the teachers is geared again to the imparting of facts. Facts, however, can be learned through a variety of media, including books and other printed material, lecture presentations on the part of the teacher, as well as discussions with other students. Hence, the supplementary use of film may fail to provide a significantly different learning experience for the experimental groups as far as the evaluative criteria are concerned. Control students are able to gain the necessary factual understanding from other sources such as the textbook, exert themselves in terms of their own particular felt needs, and, in the process, reach comparable levels of achievement relative to that of the experimental students.

In contrast to the concept of supplementary aid, a new conception is emerging--the complementary role of audio-visual media in instruction (5, 6) The underlying premise of this role suggests the following: where any task in instruction can be performed by a technological device at least as effectively as though a teacher were doing it, then such a task should be assigned to this device. This role can best be understood when described in terms of two related criteria: (1) the absolute advantage of the medium, and (2) the comparative advantage of the medium.

A technical device has an absolute advantage when it is the only means whereby certain learnings may be effected. To illustrate, students can see, in microscopic detail, the actual growth of the yeast cell only through time-lapse photography in a motion picture film. In physics, an instructor can provide a clear explanation of the operation of the stroboscope in laboratory experiments only through the use of some sequence of pictorial representations. In short, teaching procedures that draw upon cues which have greater "iconicity," that is, structural resemblance to the object or event which they represent, promise to be more effective than procedures relying upon more abstract symbolism in conveying ideas and relationships. (15) Similarly, projecting media, such as film, television, and slides, have an additional absolute advantage in channeling the attention and forming the perceptions of the students in ways not possible through other communication techniques. (13)

The comparative advantage of such media as film, television, and tape-recordings suggests that these devices be selected to provide that part of the instruction which they can perform as effectively as the teacher, and leave to the teacher the task of interacting with the students in ways that lead to deeper insights into the particular unit of instruction. For instance, a verbal and pictorial representation in a book, film, or slide-tape series may succeed as well as the teacher in explaining the operation of the stroboscope to students in the physics laboratory. However, if the teacher is so engaged, he, of necessity, is not in the position to use that time to perform tasks which only the teacher is able to perform. If, on the other hand, such a task of explanation be committed to a mimeographed handout, film, or slide-tape series capable of storing instruction, then the teacher is enabled to deal with other concerns in the instructional program that otherwise would go unattended. Hence, a film or slide-tape capable of providing instruction of at least equivalent quality makes it possible for the teacher to engage in those tasks in which the teacher has an absolute or comparative advantage over the other communications media.

When this conception of the complementary role of media is translated into teaching and learning operations in the classroom, two types of media applications emerge. One form which such usage assumes is called autonomous. On certain occasions a film or slide-tape may implement instruction in a total class or sub-group situation without the teacher actually being present. Instruction so mediated may draw upon the absolute and/or comparative advantages that the media may possess. By relieving the teacher of personal engagements on such occasions, the instructional process tends to suffer from less redundancy in the input of teaching resources than in situations where media such as films and slide-tapes are used as supplements.

A second use of communications devices is suggested by the demands and requirements of particular teaching situations and, hence, is termed situational or functionally relevant. The teaching demands presented by certain class situations may be successfully met only by the intercession of some technological device such as the overhead projector or television. For example, the size of the class may require the use of the overhead projector or television to magnify cues or the phenomena of a laboratory demonstration to provide adequate viewing for all students. In such instances, the use of the chalkboard or the actual demonstration alone may fail to meet the requirements.

The complementary use of audio-visual media is expected to facilitate the achievement of the goals of instruction in at least two ways: (1) By exploiting the comparative and absolute advantages of communications media, teachers would be relieved of some of the burden of formal presentations that are primarily of an expository nature--the introduction, elucidation, and clarification of basic concepts and generalizations. Yet, it is this type of preoccupation that often characterizes the engagement of the teacher in the classroom. Under the experimental conditions the teachers would be able to devote more time and energy to the demands involved in stimulating students and guiding their inquiry individually and in small groups. The anticipated increase in interest and self-motivation of students would tend to reduce compensatory effort in learning activities. (2) Another expected outgrowth of the complementary use of communications media is the increased interest in individual study that may be generated through the availability of audio-visual as well as printed materials on an individual or small group basis. Students who may be slow or who may have missed a presentation can review or make up work by using the available materials rather than dealing personally with the teacher. The more able student who can move faster ahead may be similarly stimulated as he avails himself of advanced content in some transmittable form (book references, films, and slide-tapes).

(2) Teacher Collaboration in Implementing Instruction

The second dimension in the experimental system is the involvement of two or more teachers in such a manner as to bring together their individual talents in ways calculated to improve the instructional program. A minimum of two teachers will collaborate in ways designed to increase student access to learning resources and commitment to individual learning. Such collaboration would yield a number of advantages: (1) It would avoid the repetition and duplication in the teaching process that commonly afflict conventional structures where each teacher acts independently in conducting teaching activities with multiple class sections in a course; (2) It would make possible greater expression of specialized interests and competencies among the teachers in the instructional program; (3) Functions of teachers may be selectively determined in cases where one teacher has more interest or greater experience in providing lecture-demonstrations to a whole class while another teacher may specialize in small group instruction or deal with individual student problems. In addition, the teachers may divide the course content among each other for special treatment, preparation, and emphasis. Theoretically, two teachers, collaborating in this manner (and combining their two sections into one "class") can plan on engaging themselves for one-half the usual number of formal lecture-presentations in a course throughout the year.

(3) Variable Class Structure

The third dimension -- variable class structure -- is related to the two preceding. Variable class size and composition may be implemented as demanded by the kinds of instructional activities seen as fitting on particular occasions. For instance, it is expected that a "large" class composed of two normal class sections may participate in some kinds of instructional activity with no loss of effectiveness when compared to conventional class structures. Essentially, the operations would involve total group instruction combined with a variety of small group and individual student activities throughout the school year. The primary criterion for such class variation will be the instructional purpose or purposes best served by a given group structure. Varying group size and composition, when allied with teacher collaboration, would increase substantially opportunities for differentiating instruction in response to differences in student understanding, interest, and commitment. It is likely that this structure would increase the frequency with which teachers are enabled to participate in small group deliberations and thus create a social climate more conducive to independent and group inquiry. Students would have greater opportunity and encouragement to probe, investigate, proffer suggestions, and hazard predictions for consideration by the group or for testing in subsequent experimentation. In an atmosphere that is socially supporting and reinforcing, that increases the number of pedagogical alternatives available to the learner, the student can be expected to exhibit increased initiative and staying power for pursuing his own learning.

An important consideration is the fact that any one class structure shall not endure so long as to acquire permanence and, thus, the rigidity of "homogeneous" class groupings. Variable class structure is calculated to reflect the immediate needs of students and the concurrent projections and present and future plans of the teachers. The essential characteristic of this dimension is that sub-grouping activities will be engaged as is seen fitting at any particular moment during the implementing of the program.

(4) Free Access to the School's Learning Resources

If teachers are to expect students to assume more responsibility for their own learning, then the school has to provide the learner with greater opportunities for choice and increased freedom of action. Immediately, it is perhaps not as important to gain the actual engagement of the student in such self-determining activities as it is to provide the student with the opportunity to decide whether he does or does not so engage himself. His decision, for instance, not to avail himself of additional opportunities provided him by the school is psychologically as important a feature of the learning environment as a decision to use the resources so made available. For, as the student makes such a decision, he is committing himself to a course of action and, whether he is aware of it or not, is implicitly assuming responsibility for his own learning or lack thereof.

Increased access to the learning resources of the school outside of formal class periods also enables the teachers to provide opportunities for learning that otherwise would not be available to students. To differentiate instruction, to enable absentees to make up work missed in class, to permit others to review material that they may not have understood -- all such occasions could be materially assisted by allowing students to draw upon selected reading material, films and slide-tapes, and laboratory facilities outside of normal class meetings. Furthermore, students interested in pursuing activities beyond minimal requirements are also enabled to do so. Though not more than six or eight students may take advantage regularly of such opportunities, their behavior would provide a model for others who may have decided to confine themselves to more conventional modes of activity.

It is readily seen that each of these four dimensions are interdependent and mutually reciprocating. The autonomous use of film in instruction, for instance, would increase the amount of free time teachers would have to devote to other functions and responsibilities. Instruction in the "large" class, on occasion, serves similarly to reduce repetition as well as some duplication in performing teaching operations. Timely subgrouping and differentiated instruction is further facilitated by the autonomous use of media and teacher collaboration. Furthermore, increased accessibility to learning resources on the part of the student would permit teachers to encourage students to draw upon these resources for certain types of assistance and thus, again, enlarge the opportunities available to the staff to engage in tasks of a higher professional order.

Interdependence of the four dimensions accentuates the necessity to manipulate each in ways that are consistent and compatible with the operation of the remaining three. For instance, if one of these dimensions of the structure were to be removed, the decrease in the degrees of flexibility that remain may be much greater than one would expect from the contribution of this one dimension alone. As one dimension is withdrawn, one can expect decreased impact of the remaining three through the constriction of alternatives open to teachers in the instructional program. In the past, research efforts have focused largely on "univariable" manipulations. The aim was to measure the impact of one variable as the others were kept "constant." The amount of change that experimental modification could generate through the univariable approach is thus of necessity limited if recognition is given to the essential inter-relationships that exist between the different components that are operating in any on-going instructional program. The effects of an experimental variable may be neutralized, at best obscured, by the effects of interaction between a number of components or agents operant in the situation as the program of instructional activities evokes its own organizational totality and a state of quasi-equilibrium. In this project these principal dimensions and their components will be manipulated in ways calculated to maximize the contribution made by each of the other components and dimensions operating simultaneously.

Finally, it is important to see the operation of each individual dimension within the context of the entire instructional program. It would not be correct to say that here is an attempt to mechanize or impersonalize the instructional process by some mechanical contrivances. Wherever such devices are used, they are designed to contribute to the kinds of freedom of choice and flexibility in a school's environment that characterize optimum conditions for purposeful and significant learning.

CHAPTER II

METHODOLOGY AND RESEARCH PROCEDURES

Selection of the Sample

In a preliminary survey by letter of thirteen suburban high schools in the vicinity of Chicago, six schools expressed sufficient interest in the proposed project to warrant follow-up interview and discussion with administrative staff and teachers. During these discussions it was pointed out to the schools that active participation in the project would require a commitment on their part in the form of appropriate facilities, equipment, and time and resources in order to engage the teachers suitably in the undertaking. Two high schools out of the initial thirteen appeared to fulfill the requirements and were chosen to participate in the program. Both schools had at least two teachers teaching full-time high school classes in physics. The schools agreed to provide the necessary equipment -- motion picture projector, an automatic slide projector-tape recorder combination, and an overhead projector -- equipment that would be allocated for the year to the science teachers engaged in the project. One of the two schools also procured closed circuit television equipment for use in total class demonstrations of physics experiments.

The project funds were used to provide the necessary films and prepare a variety of slide-tape materials and overhead transparencies for use during the year's programs. Also, the project supported the part-time, non-professional teaching assistant who worked closely in both schools with the teachers.

Initially, the plan for the project suggested inter-school comparisons between control and experimental cells. Such a design would have necessitated a larger number of independent high schools with requisite characteristics than were available to the project director. The attraction of such schools in the number required appeared unlikely and, as a consequence, a modification in the design to intra-school comparisons was introduced, a decision that led to the creation of multi-variant cell design reflecting variations in the proposed experimental teaching structure. Furthermore, establishing a design that called for intra-school comparisons of different teaching techniques provided other advantages, such as increased likelihood of obtaining student subjects in both control and experimental cells of generally comparable character and controlling the "teacher variable" as the same teachers implemented the conventional and experimental teaching strategies. In addition, the comparisons would be made in a particular school building and organization and the associated school climate, a factor of no mean importance whenever rigorous attempts are made to introduce change in the classroom and to measure the results. Finally, as the project entered into succeeding stages of implementation, it was readily appreciated that to have introduced a wider spectrum of different high schools would have been financially prohibitive and administratively impractical. A project of the scope that was envisioned and implemented made necessary continuous and ready access to teaching materials, equipment, and facilities, and required regular and frequent visitation on the part of the project director and specialized resource personnel in graphic preparation and measurement and evaluation during sustained periods of the project.

While it was recognized that the selection of control and experimental cells and their corresponding treatments within the same school and involving the same teachers presents the danger of contaminating the impact of comparative methods and the assessment of results, the advantages in introducing this experimental design clearly outweighed the disadvantages. Nevertheless, the possibility of such contamination was recognized and ascertained by the research staff and teachers and constant effort was made to keep control and experimental procedures distinct throughout the year. Furthermore, the dimensions comprising the experimental structure were such as to permit effective confinement of teaching methods to the appropriate student class groups designated as experimental and control . The experimental structure provided, in the main, a new organizational context and its inherent possibilities for greater variety in student and teacher engagement, and not particular teaching pedagogies that could be easily transferred by an individual teacher from one group to another.

Experimental Design and Comparative Treatments

Both high schools selected for the project were characteristic of educational institutions in middle class communities. The majority of the students were destined for college entrance following high school graduation. All students in the project were pursuing a matriculation course of study. They were grouped into appropriate class sections according to the procedures determining time table schedules in the particular schools. No attempt was made to assign students randomly to certain classes, nor to assign class groups to control or experimental cells. It was assumed that, by and large, the school's procedures for class sectioning led to a distribution of those relevant characteristics of the learner in a fairly random fashion. Except for the formation of "accelerated" classes in physics in one of the two schools, all the other class sections in both schools were determined primarily by administrative and strategic factors in devising a workable time schedule for the individual student. The presence of accelerated classes in the one school required that they be assigned in a way that would not inject a positive bias in favor of the experimental method in the analysis of the results. Their treatment is described below in the experimental design within School B.

School "A"

As a result, one school, hereafter referred to as School A, provided four separate class sections and two physics teachers which could be deployed in the manner postulated by the control and experimental procedures.

FIGURE 1. Experimental Design in School "A"

Control Group - Period 1		Experimental Group - Period 3
Conventional Class Organization and Management		Class Organization and Management as per Dimensions 1,2,3,4
Regular Class Teacher 1	Regular Class Teacher 2	Two Classes Combined Teachers 1 and 2

The treatment called for the implementing of all four dimensions in ways calculated to create an optimum environment for teaching and learning. Unfortunately, as the program got underway in School A, serious difficulties were encountered early in the school year which appeared to make impractical the full application of three of the four dimensions in the manner originally proposed. For instance, the teachers in School A discovered that their "large" classroom did not accommodate the total experimental class in a way considered feasible and operationally acceptable. Therefore, virtually no "large class teaching" was performed by either one of the teachers; this strategy was employed occasionally whenever a film or slide-tape was to be shown to the whole experimental class. As a consequence, the two teachers in School A failed to benefit by the opportunity to reduce repetition and duplication in the performance of teaching tasks. In addition, classroom space and facilities were found unsuitable for employing varying class groupings as a suggestive strategy following one or a series of class periods of total group instruction.

However, School A introduced a modified "variable class structure" by creating a fairly stable and separate division of two sub-groups, "upper" and "lower" halves, each taught by one of the teachers largely independent of the other. This division was introduced at the end of November and only minor shifts in composition were effected on the basis of student performance on subsequent tests in the course. Except for the alternation of teachers between the two sub-groups (at the midpoint of the second semester), the teaching of these sections assumed a typically conventional form. In any event, flexible and timely differentiation of instruction that was expected as an important outcome of variable class structure was not realized to the extent anticipated and projected by the initial formulation of the program.

Finally, it was discovered that the fourth dimension, free access to the learning resources, could, at best, be only minimally achieved since, again, the facilities initially thought suitable were found to be inadequate for the proper exploitation of this dimension. As a consequence, on only a few occasions, such as students making up work missed in previous class sessions, was it possible to provide learning opportunities outside of formal class time on this "free access" basis in the experimental program in this school.

Nevertheless, the assessment of the experimental structure in School A served to provide a basis for evaluation under conditions recognized as less than adequate. In the light of the great diversity in physical plant, available resources, and administrative feasibility of change that characterizes the school scene throughout the country, experimental teaching procedures are more adequately assessed as they are introduced under conditions of varying acceptance, support, and suitability.

School "B"

School B, on the other hand, made available a total of eight physics classes and their two teachers and thus presented the possibility of introducing two variants of the experimental structure involving the four dimensions described in Chapter I. As a result, it was possible to introduce an experimental design comprising three cells -- one control and two experimental.

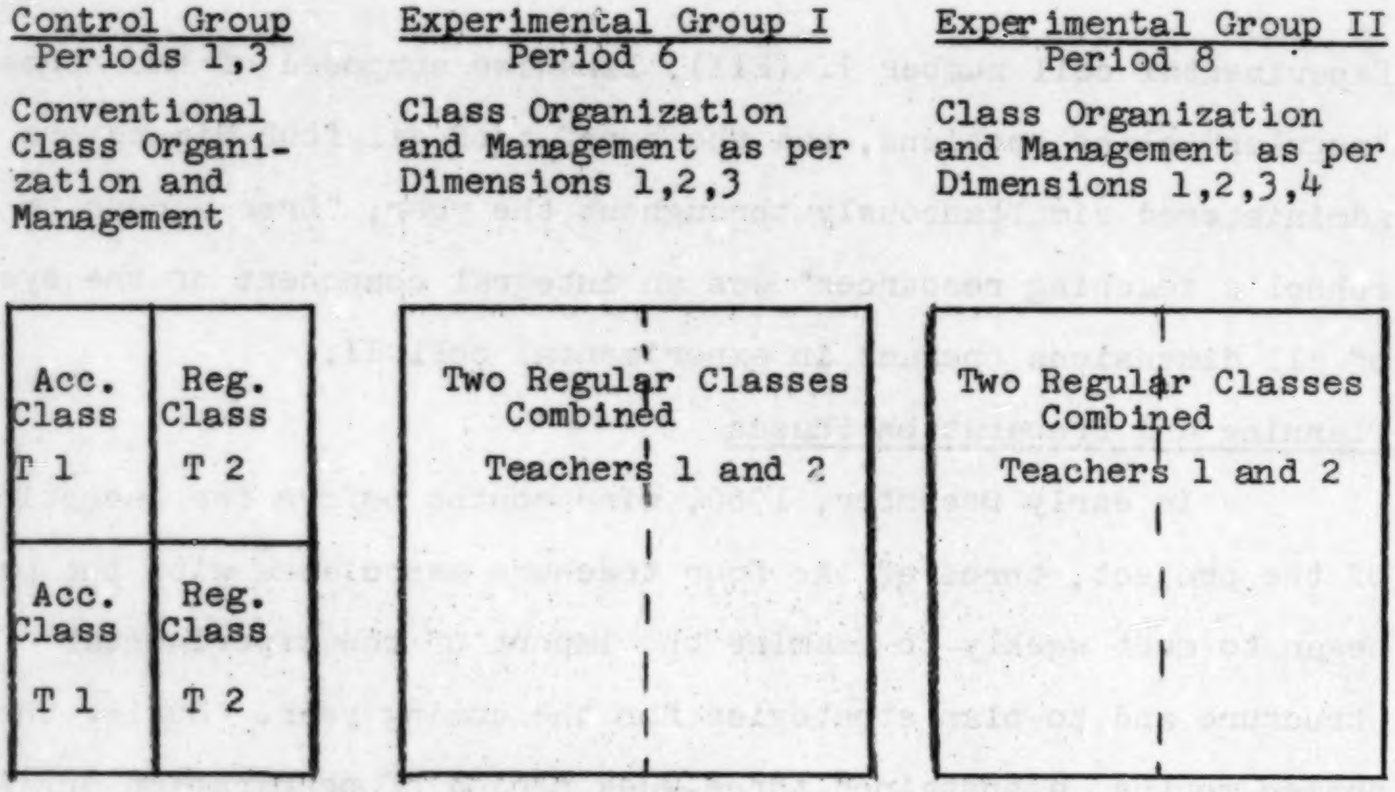

Control Group
Periods 1,3
Conventional Class Organization and Management
Experimental Group I
Period 6
Class Organization and Management as per Dimensions 1,2,3
Experimental Group II
Period 8
Class Organization and Management as per Dimensions 1,2,3,4
Acc. Class
T 1
Reg. Class
T 2
Acc. Class
T 1
Reg. Class
T 2
Two Regular Classes Combined
Teachers 1 and 2
Two Regular Classes Combined
Teachers 1 and 2

FIGURE 2. Experimental Design in School B

Since School B's program in physics was already predicated on some preliminary selection of students (according to previous achievement in math and science) and the resulting creation of two "accelerated" classes, it was decided to regard these two classes and two "regular" classes as the "control" groups to be taught in a conventional manner by the two teachers engaged in the program. Two other "regular" classes meeting at the same hour were combined into one class section to form experimental group number I (EI) and to which three of the four dimensions were administered: (1) complementary role of audio-visual technology; (2) teacher collaboration with the two teachers together implementing the instruction of this group; and (3) variable class structure and differentiation of instruction. The fourth dimension was omitted from this cell in an effort to determine the extent to which "free access" is instrumental in altering the impact of the other three dimensions on relevant learning outcomes.

Experimental cell number II (EII), likewise composed of two normal "regular" class sections, had the benefit of all four dimensions administered simultaneously throughout the year; "free access to the school's teaching resources" was an integral component of the system of all dimensions operant in experimental cell II.

Planning and Preparation Phases

In early December, 1960, nine months before the inception of the project, three of the four teachers associated with the program began to meet weekly to examine the import of the experimental structure and to plan strategies for the coming year. During the summer months, a sustained three-week period of preparation engaged the teacher participants, during which final arrangements were made for the beginning of the school year in September.

Curriculum Planning -- One of the important tasks facing the group was to outline the content of the physics course in a way that would reflect upon the objectives each of the teachers agreed were important to achieve. In this undertaking, the teachers and project staff were favored by the availability of the newly created curriculum in modern physics designed by the Physical Science Study Committee, a curriculum that had already been introduced on an experimental basis in both schools and was accepted as the course of study in physics in these institutions for the year 1961-62. This curriculum provided the project with a prepared collection of materials, including student textbook, laboratory manual, teacher's guide, approximately fifty film titles, and a miscellaneous stock of tools and materials for laboratory experimentation -- all of which were carefully planned to correlate with each other in a "system" of instructional materials. The PSSC curriculum provided the project personnel with modern physics subject matter already ordered in an acceptable way. As a result, all members were enabled to focus upon the experimental considerations represented by the program. Of particular importance was the availability of the film series which was produced to serve specific purposes, such as bringing scientists and complicated physics demonstrations into the classroom, a resource which otherwise would not have been available to teachers and students in the physics course.

Clarification of Basic Objectives -- It was necessary, however, to obtain the agreement of all teachers upon the primary objectives toward which the program would be geared. While attention would be directed to the effective understanding of the subject matter content and the development of problem-solving skills in dealing constructively with problems in physics, the teachers agreed that the whole program must be committed to cultivating the student's interest in inquiring into problems in physical science and also to generating in the student a capacity and a readiness to assume responsibility to pursue his own learning. These ultimate objectives were recognized as important guidelines for their teaching in both control and experimental classes. The focus of the project, therefore, was centered upon the extent to which teachers functioning under conventional and experimental conditions were enabled to bring about improvements in student learning and changes in non-cognitive behavior as reflected by and contained within these objectives.

The Articulation of the Experimental System's Operation -- Considerable attention and discussion was directed at the operational details and implications of the four dimensions of the experimental structure.

The potentialities of film, tapes, overhead projection, and television were examined and studied in relation to their autonomous and functionally relevant use in instruction in accordance with the complementary role postulated in the project. How two teachers would embark on collaboration and carry out instruction together was studied with considerable intensity. In this connection, the experiences of other teachers and schools were examined for suggestive possibilities in the experimental program. During the summer preparation period, one morning was devoted to a visit and discussion with teachers and administrators of the University of Chicago Laboratory School where a number of projects had been conducted involving team teachers and flexible class groupings in the interests of cultivating student initiative and independence in learning. The broad outlines of implementing various class groupings were established and hypothetical examples were constructed in order to appraise the possibilities as well as identify areas where problems would arise in the application of this dimension. The "free access" dimension was regarded with particular interest by all teachers as requiring within the classroom environment some decision on the part of the student as to the pursuit of his own learning when the opportunity to do so is a generic constituent of the program. The procedural conditions under which the students would be permitted to engage in such "free access," the arrangement of physical conditions for previewing audio-visual materials, the conducting of experiments in the laboratory, the manner in which such free access activity would be controlled and supervised, the advisability of establishing conditions which students participating in this activity would have to observe -- all these considerations were carefully studied and decisions were arrived at in preparation for the experimental year.

In the course of this planning phase, it was early recognized that suitable classroom facilities in the form of adequate space, seating arrangements, and the use of audio-visual media would have to be created, an assessment that led one of the schools to make fairly extensive innovations in their physics classroom-laboratory. Also, the same school decided to install closed circuit television equipment in this classroom in order to facilitate demonstrations in physics for the large experimental class.

Preparation of Materials -- In the course of planning the curriculum and outlining the operations suggested by the experimental structure, possibilities were identified for the appropriate use of slide-tape instruction and overhead projection of transparencies, the preparation of which was subsequently begun during the same series of weekly meetings. The planning and preparation of these materials was accomplished through the full-time participation of the graphics specialist who worked closely with the teachers in this activity. The preparation of material continued throughout a large part of the following experimental year ahead of the timetable scheduling their use. Eventually, 24 slide-tape series were completed and over 125 overhead transparency composites were prepared to integrate with the film, textbook and reading material, and the presentation-demonstrations that were to be conducted by the live teacher in the classroom.

Measurement and Evaluation -- Toward the latter part of the preparation phase, attention was directed at the need for tests, measurements, and other data-collecting instruments that would provide the necessary information for making defensible comparisons between control and experimental teaching procedures. Also, a schedule of the evaluation proceedings was determined, calling for basically three periods of instrument administration and data collection from students, in addition to other forms of information provided by the teachers and the teacher assistant in log form throughout the school year.

Measuring Instruments and Data Collection Procedures

Dependent and Independent Variables

The evaluation of the impact of experimental and control procedures was based upon the following dependent variables:

(1) understanding of and solving problems in physics matter;

(2) attitude toward the scientist, the scientific method, and the inter-relationships between science and society;

(3) student perceptions of responsibility for performing selected learning tasks and engaging in learning activities;

(4) student assessment of the physics course in relation to other courses and some selected characteristics of the program;

(5) teaching operations and logistics as engaged in by the teachers and teacher assistants that were unique outcomes of the experimental structure.

The independent variables were:

(1) Mental Age of the Student -- Mental age, rather than I.Q., was used as an independent variable in order to

obtain a more useful measure of the existing differences in demonstrable capacity among students in these two schools and in the experimental project. It was important to assess the student's present development in intellectual maturity as one determinant of his actual performance in the course and not locate his position in relation to a population norm as represented by the corresponding I.Q. measure of a person's mental age.

(2) Previous Math Grade -- This measure was obtained from the information card completed by each student at the beginning of the school year. Values of one to four were assigned to the grade range of "D" to "A" respectively. In the event that a student recorded more than one math course (e.g., algebra, geometry, and trigonometry), the numerical values of all of the grades were averaged to provide one numerical score in math.

(3) Previous Science Grade -- A similar numerical value was obtained for the student's score in science using the procedure described in (2) above.

(4) Future Vocation -- The future vocational choices of the students were classified into "science" or "non-science related" and given a value of 1 and 0 respectively. Vocations that were "science-related" included fields such as engineering, dentistry, high school science teacher, etc. Vocations that were

classified as "non-science related" were such areas as salesmen, business management, law, social studies teacher, etc.

Data Collecting Procedures

I. Basic Student Information

A. A student information card was completed at the beginning of the year. Information on this card included previous math and science grades, plans for college, and future vocational choices. A copy of this information card can be seen in Appendix F.

B. The California Short-Form Test of Mental Maturity (1957, S-Form, Secondary, Form A, Grades 9 to 13) was administered to all students involved in the project.* In order to standardize the administration of the test in both schools, the instructions were taped, and the tape -- which included silent timed intervals for each section of the test -- was played during each administration. The IBM answer sheets were mechanically scored and raw scores were obtained for seven separate tests: Spatial Relationships Factor: Test 1 -- Sensing Right and Left, Test 2 -- Manipulation of Areas; Logical Reasoning Factor: Test 3 -- Similarities, Test 4 -- Inference; Numerical Reasoning Factor: Test 5 -- Number Series, Test 6 -- Numerical Quantity; Verbal Concepts Factor: Test 7 -- Verbal Concepts. These scores were then used to compute the language raw score, non-language raw score, mental age score in the language and non-language tests, average mental age score, and the I.Q. score.

---

* Information about and copies of this test are available from the California Test Bureau, Del Monte Research Park, Monterey, California. An instructional manual for the administration of the test and a technical report of its reliability are also available.

II. Periodic Evaluation

Periodic evaluations were obtained through the systematic administration of formal instruments during three periods of the year. A second form of data collection was instituted through a continuing recording on logs of information by the teachers and teacher assistants of their daily activities and by listing the names and activities of students who appeared daily during the free access period.

A. Periodic Evaluation Phases

1. Pre-Evaluation Phase, September, 1961

a. Pre-test (achievement) -- thirty-six item test was constructed by the test and measurement consultant in collaboration with the teachers in the program. Total and sub-scores on "lower" and "higher" mental processes were obtained through the administration of this test. The pre-test is reproduced in full, along with sub-score categories, in Appendix A.

b. Attitude Inventory -- This instrument was adapted from an instrument prepared by the Science Manpower Project, Teachers College, Columbia University, called the Allen Inventory of Attitudes Toward Science and Scientific Careers. Total and sub-scores were obtained on the scientist, method of science, and society and science. Following the decision to use this instrument, toward the end of the summer planning period, it was discovered that the instrument had been so constructed as to make it difficult to obtain composite scores from the students who responded to the items contained therein. As a result, an attempt was made to validate these items by administering the test to a group of selected scientists and science teachers at the University of Chicago, University of Chicago Laboratory School, and selected public schools in the Chicago vicinity. As a result of this administration, only those items were used with which at least 75% of the judges either agreed or disagreed. Appendix E contains a copy of the instrument and identifies those items that were counted for purposes of obtaining a score for the student. The weighting of the responses was done on a one-to-five point scale.

c. Q-Sort Instrument -- Twenty-eight teaching-learning tasks were identified, party from Bloom's Taxonomy of Educational Objectives (1), and partly from the identification of relevant operations growing generally out of the teachers' experiences and having high relevance for the experimental program. These tasks were placed on 3x5 cards individually and sorted by both student and teacher as to whose job it was to perform them. Four categories of task-agents were established -- teacher, student, student and teacher, and neither. The weighting of the sorts was scaled from one to four points, one representing the "neither," two the "teacher," three the "student and teacher," and four the "student." Total and subscores were obtained on tasks dealing with evaluation, problem-solving, and learning activities. The instrument is reproduced in Appendix C.

2. Mid-Year Evaluation Phase, January, 1962
   - a. Q-Sort Instrument -- Administered in the same manner as in Pre-Evaluation Phase in (c) above.
   - b. Student Opinionnaire Survey -- A rating and ranking of the physics course in comparison with other courses taken by the student on a scale of one to ten on nineteen items. This instrument of initially eighteen items (the nineteenth item was added for this project) was prepared by Dr. Herbert A. Thelen as part of a research study on teachable classes (20). This instrument is reproduced in Appendix D.
3. Post-Evaluation Phase, June, 1962
   - a. Post-test (achievement) -- A fifty-nine item test was constructed by the test and measurement consultant with the teachers' assistance, items for which were selected partly from periodic tests given by the teachers throughout the year in the course, partly from items on the pre-test, and also from ten unit, semester, and final tests prepared

under the auspices of the Physical Science Study Committee for use in the modern physics high school course. Again, total and sub-scores for "lower" and "higher" mental processes were obtained. The test is contained in Appendix B.

b. Gain Scores (achievement) -- This score was obtained for each student by subtracting pre-test results from post-test results for total scores and sub-scores.

c. Attitude Inventory -- The same instrument was administered as in the Pre-Evaluation Phase (b) above.

d. Q-Sort Instrument -- This sort was completed once again by students and teachers as in the Pre-Evaluation and Mid-Evaluation Phases, except for one modification: an additional sort by students and teachers as to what agent(s) actually did perform the task most often during the year. As before, total and sub-scores were obtained for the three categories of teaching-learning tasks or operations.

e. Student Opinionnaire Survey -- This instrument was administered in the same manner as in the Mid-Year Evaluation Phase, with the addition of items 20 - 29.

III. Continuous Data Collection

A student information card was completed at the beginning of the year. In addition, four forms of record and data collection procedures were instituted to reflect the weekly and daily operations of the program in control and experimental classes.

A. Weekly outlines were developed by the collaborating teachers indicating the teaching plan for the week for their group and the nature of the collaboration, use of audio-visual media, and subgrouping procedures.

B. Collaborating teachers maintained daily logs which recorded the actual teaching tasks in the formal classroom and their corresponding time periods as well as extra-class involvements.

C. The teacher assistant similarly maintained a daily log of her participation and the time periods throughout which such engagements occurred.

D. A daily record was maintained by the teacher assistant of all students in experimental group EII in School B and in the experimental class in School A taking advantage of "free access" to the learning resources in the science department.

A description of the above-mentioned schedules and logs is contained in Appendix G.

Statistical Methods Comparing the Outcomes of Control and Experimental Procedures

All the data collected in the periodic evaluation phases and the student information cards were committed to IBM form and processed by a computer program, developed by the test and measurement consultant, which had the capacity to handle seven dependent and four independent variables simultaneously. Analyses of variance and covariance were obtained through the programming of this data;

data on the independent variables of mental age, previous math grades, previous science grades, and vocational choice was used to adjust the scores of students on the dependent variables in order to provide corrected mean scores for control and experimental classes in comparing the conventional and experimental teaching procedures. The statistical procedures on which the analysis program was based are found in the manual prepared by Kerlinger.[1]

A Sample of the Experimental Structure in Operation

It may be opportune to describe the practical procedures characterizing the implementation of the four major dimensions as they were translated into practice during the experiment. An example may be drawn from a series of activities engaged in by the two teachers of School B during a two-day period in the early fall of the school year. On the first of this series of class periods, the teachers planned to review the mathematical procedures involved in the appropriate graphing of scientific data. During the preliminary phase it was decided that such a review could be accomplished quite adequately via a short slide-tape presentation describing the nature of the procedure and the considerations involved in constructing graphs that best represent relationships between two sets of data. The slide-tape, thus prepared, extended through twelve minutes of running time and included thirty slides.

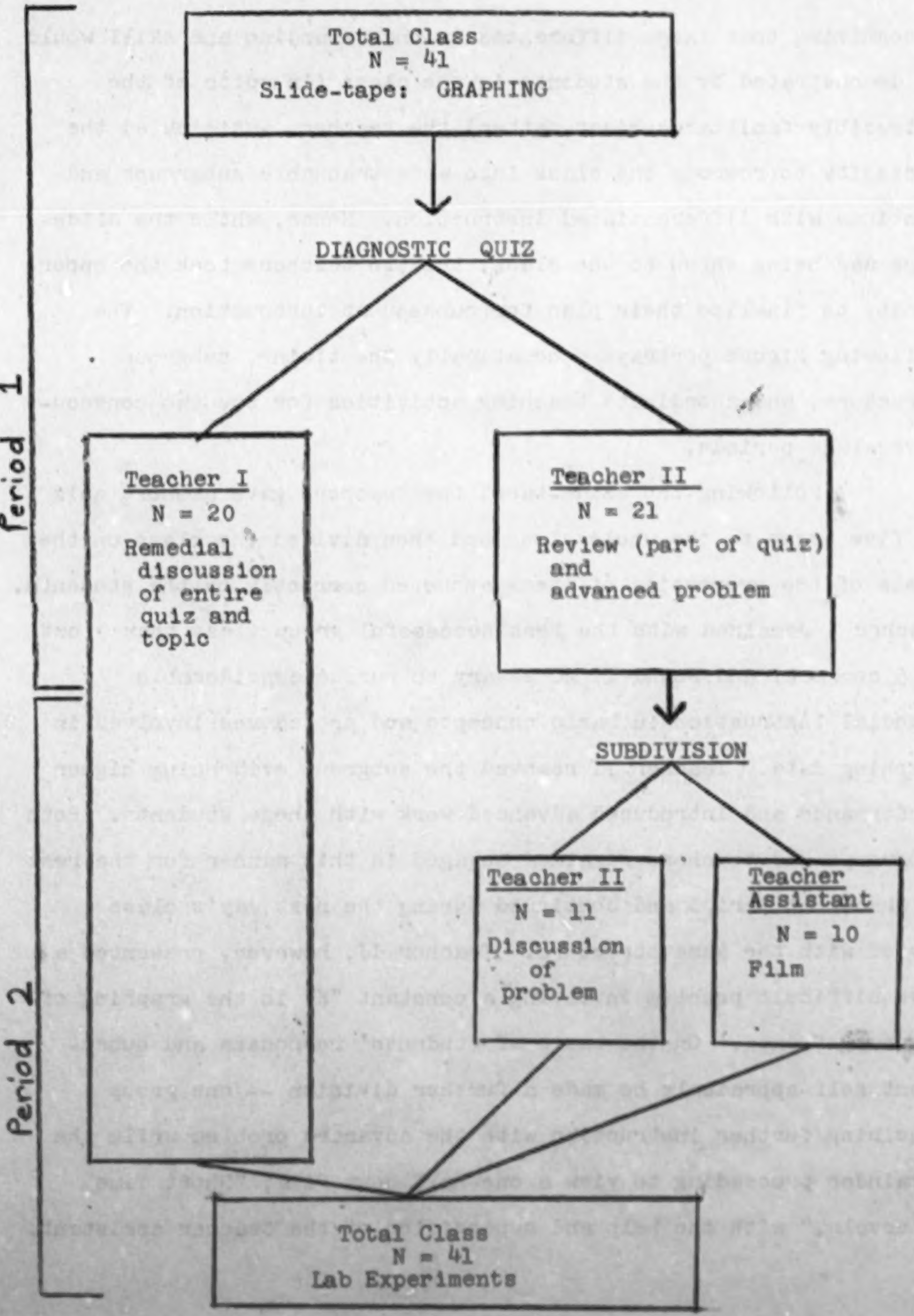
The class meeting in each experimental group began with the showing of the slide-tape, "Techniques for Graphing Functional Relationships," which was projected by the teacher assistant.

---

[1] 1. Frederick N. Kerlinger, Research Design and Analysis of Variance, A Manual for Students of Education (New York: School of Education, New York University, 1957).

Recognizing that large differences in understanding and skill would be demonstrated by the students in the class (in spite of the ostensibly familiar subject matter) the teachers anticipated the necessity to regroup the class into more teachable subgroups and continue with differentiated instruction. Hence, while the slide-tape was being shown to the class, the two teachers took the opportunity to finalize their plan for subsequent instruction. The following figure portrays schematically the timing, subgroup structure, and coordinate teaching activities for the two consecutive class periods.

Following the slide-tape, the teachers gave a short quiz of five items to the whole class and then divided the class on the basis of the proportion of items answered correctly by the students. Teacher I remained with the less successful group (less than 3 out of 5 correct) and found it necessary to pursue considerable remedial instruction in basic concepts and procedures involved in graphing data. Teacher II removed the subgroup evidencing higher performance and introduced advanced work with these students. Both subgroups and teachers remained engaged in this manner for the rest of the first period and continued during the next day's class period with the same structure. Teacher II, however, presented a more difficult problem involving a constant "K" in the graphing of a group of data. On the basis of students' responses and subsequent self-appraisals he made a further division -- one group requiring further instruction with the advanced problem while the remainder proceeding to view a one-half hour film, "Short Time Intervals," with the help and supervision of the teacher assistant.


Total Class
N = 41
Slide-tape: GRAPHING
DIAGNOSTIC QUIZ
Period 1
Teacher I
N = 20
Remedial discussion of entire quiz and topic
Teacher II
N = 21
Review (part of quiz) and advanced problem
SUBDIVISION
Period 2
Teacher II
N = 11
Discussion of problem
Teacher Assistant
N = 10
Film
Total Class
N = 41
Lab Experiments

The teachers had considered this film too difficult for most students in the class and therefore not suitable for total class viewing.

Toward the close of the second period, all members of the class reassembled in the laboratory to conduct a series of experiments from their lab guides requiring the collection and graphing of data.

A number of plus factors will be readily observed when one examines the nature of the experimental structure in operation in Figure 3. Both teachers had additional opportunity, while the slide-tape was being shown to the total class, to plan follow-up activities. They were enabled to specialize in focusing upon different sets of problems in their respective subgroups. It is likely that Teacher I could provide his group with more thorough remedial work than is normally feasible in a conventionally ordered classroom. The group instructed by Teacher II would, in all likelihood, have been denied the opportunity to investigate the procedures posed by the more complex data involving a constant "K." A sustained treatment of the more difficult problem, as introduced by Teacher II, would also not have been likely of attainment had these two teachers been functioning independently in separate classes. Finally, the small group of students who appeared as the most capable performers in the whole group would not have had the opportunity to view the film "Short Time Intervals" in a conventional classroom situation.

Free Access to the School's Resources

In practice, this dimension was implemented only in School B to any systematic extent. In September it was decided that all students in Experimental Group II be permitted to come to the science laboratory for their one-half hour study period (rather than remain in study hall or the library) to pursue work in physics. Toward the end of November, however, it was decided to place certain conditions upon "free access" by requiring each student to identify one or more activities in which he planned to engage himself during the period. The teacher assistant in School B supervised these periods and recorded the names of the students attending on a daily log. Generally, one of the two teachers was present within the classroom area to provide assistance to students if necessary.

CHAPTER III

RESULTS

Since the experimental system was instituted to varying degrees of comprehensiveness in the two schools participating in the project, the results of this study are presented according to the data obtained from each of the schools separately. Results from School A are presented first.

School A

It will be remembered that the four dimensions of the experimental structure -- complementary role of audio-visual media, teacher collaboration, variable class structure, and free access -- were instituted only to a minimal extent in School A. As was mentioned in the chapter on Procedures, only the dimension of complementary role of media was manifest to a respectable degree -- (the teacher assistant projected films and slide-tapes for the whole experimental class and occasional subgroups); teacher collaboration, as defined in this study, was practically non-existent except as the two teachers participating in the project carried on coordinate but separate activity within their half sections; and "variable class structure" was instituted in a fairly stable form toward the end of November when the experimental group was reconstituted into "upper" and "lower" halves, each of which was then instructed rather conventionally by one of the two teachers, with the teachers alternating between these subsections three times during the remainder of the year. "Free access" was represented by the occasional, but hardly significant, use of film and slide-tapes largely in the form of makeup work on the part of students who had missed classes.

Comparative Results on the Independent Variables

The following table shows the scores obtained by the control and experimental classes on the California Test of Mental Maturity (mental age), their previous math grade, previous science grade, and vocation (science or non-science related).*

TABLE 1

Mean Differences for Scores on Independent Variables

School A

Group	Mental Age	Previous Math	Previous Science	Vocation
$C_{(N = 46)}$	221.15	24.52	23.06	.78
$E_{(N = 34)}$	218.79	27.20	26.94	.91
Analysis of variance (F)	.46	1.72	1.76	.69

In applying analysis of covariance throughout this study and correcting the mean scores of dependent variables, it was found that, by and large, mental age and previous math grade were the two independent variables that appeared to exert the greatest amount of effect in modifying F values obtained through analysis of variance. Therefore, in order to simplify the reporting of the data, the independent variables of previous science grade and vocation will be dispensed with in most instances and the focus will be placed upon the results obtained in the analyses of covariance when corrections are made for differences in mental age and previous math grade.

---

*The previous-math and previous-science grade points were multiplied by ten for greater convenience in handling the data on IBM cards.

Comparative Results on the Dependent Variables

Dependent variables were of four different types: (1) cognitive achievement as measured by the gain score as the difference in scores on the pre- and post-tests; (2) relative change in attitude to the scientist, scientific method, and science-society interrelationships; (3) assessment of the physics course by students as obtained through the student opinionnaire survey instrument; (4) the Q-sort data reflecting relative changes in the way the students perceived the tasks involved in teaching and learning activities and the corresponding agent or agents who were to perform them. In addition, subscores were obtained on all four of these dependent variables, the reporting of which will be done only in instances where important differences appear between the total mean scores of the control and experimental classes.

(1) Cognitive Achievement. The mean gain scores of the comparative groups and the standard deviations are shown in Table 2.

TABLE 2

Mean Differences in Gain Scores -- School A

Group	Mean Gain Scores	Standard Deviations
$C_{(N = 46)}$	17.08	6.497
$E_{(N = 34)}$	17.61	5.989
Analysis of Variance (F)	.13	

Relatively little difference exists between the mean gain scores of the two groups and this difference is reflected in a low F value of .13 in the analysis of variance. Subsequently, little change in analyses of covariance was observed when the mean scores were corrected for differences in mental age and pre-math grade, .32 and .00 respectively.

(2) Attitude to the Field of Science. Pre- and post-administrations of the attitude instrument were given to the control and experimental classes and the corresponding mean scores of the groups are shown in Table 3.

TABLE 3

Mean Differences in Pre and Post Attitude Scores

Group	Mean Scores Pre	Mean Scores Post	Standard Deviations Pre	Standard Deviations Post
$C_{(N = 46)}$	220.13	219.84	17.62	12.87
$E_{(N = 34)}$	223.88	212.79	15.13	18.84
Analysis of Variance (F)	.40	3.95		

What began at the outset with a slight mean difference in favor of the experimental groups (though not significant with an F ratio of .40 in analysis of variance) concluded at the end of a year with a marked decline in the mean score of the experimental group and little change in the mean score for the control group. The mean difference of seven points in the post administration of the attitude instrument produced an F value of 3.95 in the analysis of variance which, when corrected for differences in the pre-math grade of the students, was increased to 5.71. The next table provides the data involved in the analysis of covariance.

TABLE 4

Significance of the Difference in Mean Scores

Source of Variation	D.F.	Sum of Squares	Variance
Between	1	1320.96	1320.96
Within	77	17783.26	230.95
Total	78	19104.23	5.71 (F)

This F value of 5.71 is well beyond that required for significance at the 5% level (3.98 with 70 df) and is considered significant for the purposes of this study. An effort was then made to identify the subscore(s) which produced this difference in the total score. In examining the subscores for attitudes toward the method of science, the person of the scientist, and science-society interrelationships, it was discovered that the greatest amount of relative change in favor of the control groups occurred in the subscore of items relating to the person of the scientist. The following table shows the F ratio of 6.80 obtained through analysis of variance.

TABLE 5

Significance of Differences in Pre and Post Mean Subscores -- Scientist

Group	Mean Subscores Pre	Mean Subscores Post	Standard Deviations Pre	Standard Deviations Post
$C_{(N = 46)}$	64.00	63.54	6.285	5.357
$E_{(N = 34)}$	64.00	59.73	6.276	7.601
Analysis of Variance (F)	.00	6.80		

This F value was further increased to a value of 9.89 when corrected for differences in the pre-math grade. Even on the basis of analysis of variance, the difference here must be considered significant since it approaches the 1% level of significance (7.01 with 70 df). Similarly, scores on items dealing with science-society interrelationships reveal a slight mean difference at the beginning of the year in favor of the experimental group. Note in the following table how the relative differences in the mean scores on this sub-category change in favor of the control group at the end of the school term.

TABLE 6

Mean Differences
on
Pre and Post Subscores -- Science-Society

Group	Mean Subscores Pre	Mean Subscores Post	Standard Deviations Pre	Standard Deviations Post
$C_{(N = 46)}$	96.26	96.80	8.868	6.807
$E_{(N = 34)}$	99.38	95.64	6.835	6.777
Analysis of Variance (F)	2.13	.31		

The highest F ratio in analysis of covariance (corrected for differences in mental age) was 3.05 on the pre-administration mean score and the corresponding F value in the post-administration mean differences was .22, suggesting a shift in the relative differences in the responses of students to the items on science-society interrelationships in favor of the control class. A similar relative shift occurred in the subscore dealing with the scientific method -- 60.50 and 59.86 were the corresponding means for the experimental and control classes respectively at the beginning of the year, and 57.41 and 59.50 at the end of the year. The highest F value of .12 (corrected for math grade) at the beginning of the year changed to an F value of 3.09 at the end of the year in favor of the control groups again. While the F values for the subscores dealing with science-society and the method of science do not approach significance at the 5% level, they are consistent with a tendency of attitude scores to favor the control class in School A.

(3) Student Opinion Survey (SOS) -- Course Assessment. A similar outcome favoring the control classes occurred in students' assessments of physics in relation to their other courses. Changes in the mean differences in the two administrations of the Student Opinion Survey, in January and in June, and their relative significance can be seen in the table below.

TABLE 7

Mean Differences in Course Assessment
in January (I) and June (II) -- Student Opinion Survey

Group	Mean Scores I	Mean Scores II	Standard Deviations I	Standard Deviations II
$C_{(N = 46)}$	129.80	122.80	19.22	26.32
$E_{(N = 34)}$	117.76	110.00	29.02	35.49
Analysis of Variance (F)	6.62	3.53		

In correcting the means in the second administration for differences in pre-math grades among the two groups, it was discovered that the F value was boosted from 3.53 to 4.42.

TABLE 8

Significance of the Difference in Mean Scores -- SOS II

Source of Variation	D.F.	Sum of Squares	Variance
Between	1	4051.74	4051.74
Within	77	70551.27	916.25
Total	78	74603.02	4.42 (F)

This F value of 4.42 becomes significant at better than the 5% level with 70 df. The control group assessed the physics course significantly more favorably than did the experimental group.

(4) Q-Sort Data*- Students in both groups sorted the twenty-eight teaching-learning tasks according to who they thought was responsible for performing them -- student, teacher, student and teacher, or neither. They sorted these tasks three times throughout the year -- in September (I), January (II), and June (III). Table 9 reflects changes in the mean scores of the groups throughout the three administrations.

---

* Reliability data for this instrument will be found in Appendix C.

TABLE 9

Mean Differences in "You" Sorts I, II, III

Group	Mean Scores I	II	III	Standard Deviations I	II	III
$C_{(N = 46)}$	74.28	76.13	76.82	4.219	5.022	4.503
$E_{(N = 34)}$	73.35	74.35	73.64	4.61	4.29	5.22
Analysis of Variance (F)	.87	2.76	8.50			

It can be observed that there was an increasing shift in favor of the controls as the students sorted the tasks throughout the year. The highly significant F value of 8.50 in June is further increased to an F of 9.76 when the mean difference is corrected for initial differences in pre-math grade. An F value of greater than 7.01 (70 df) makes this mean difference in the June sort significant beyond the 1% level. The control group assigned relatively greater responsibility to the student over the year than did the students in the experimental group.

Which subscore category(ies) might have produced this difference in total scores through the year in the "you" sorts of the students? When the data is examined, it is noticed that the subscore category of "inquiry" or problem-solving had exerted predominant impact in contributing to the significant differences in the total scores. For instance, the F values from the analysis of variance of the mean scores on the subcategory of "inquiry" tasks changed from .00 in September to 7.32 in January and 14.20 in June. By correcting for differences in pre-math grade, analysis of covariance served merely to strengthen this conspicuous development -- .00 in September, 9.10 in January, and 18.31 in June. Table 10 shows the group means and the corresponding F values of the differences between experimental and control groups in School A on the scores for inquiry tasks on the Q-sort when the student sorted them according to who he thought was the appropriate agent to implement these tasks.

TABLE 10

Mean Differences in "Inquiry" Subscores - "You" Sort I, II, III

Group	Mean Scores I	II	III	Standard Deviations I	II	III
$C_{(N = 46)}$	28.21	29.19	29.41	2.430	2.663	2.646
$E_{(N = 34)}$	28.17	27.52	27.32	2.166	2.798	2.156
Analysis of Variance (F)	.00	7.32	14.20			

It is evident that the control classes demonstrated changes in the perception of the students of their responsibility to perform tasks involving inquiry in physics of a magnitude significantly greater than that demonstrated by students in the experimental group. The resulting difference is significant much beyond the 1% level.

Subjects in both groups also sorted these tasks according to how they thought the teacher would sort them in September (I), January (II), and June (III). The table of mean scores and corresponding analysis of variance F values is shown below.

TABLE II

Mean Differences in
Scores of the Subjects' "Teacher" Sorts - I, II, III

Group	MEAN SCORES			
	I	II	III	
			Teacher I	Teacher II
C (N = 46)	76.71	80.47	80.35 (N = 23)	80.52 (N = 23)
E (N = 34)	72.20	75.20	77.11	81.54
Analysis of Variance (F)	8.43	15.53	2.57	.20

It must be noted that students in the C group in September identified the "teacher's" expectations of an order considerably higher (F = 8.43) than the corresponding level of the E students' perceptions of the "teacher's" expectations. This disparity was increased in January and modified in June where the difference in mean scores only for "Teacher I" promises to be real. Clearly, the control group viewed the "teacher" -- what and how much he expected of the student (the higher the score, the greater the student's responsibility) -- as more demanding than did the experimental subjects during at least the first half of the school year.

In June it was decided to have the experimental subjects sort the tasks as to "how the teacher would sort them" twice, once for each of the two teachers who were collaborating in the instruction. As a result, sort III provides the basis for a comparison between the control and experimental students' identifications of the expectations of each of the two teachers in the program. This accounts for the change in N in the control group data to twenty-three, the number of students in each of the conventional class sections in the control cell.

In sort III, a mean difference of some magnitude appeared with reference to the students' sorts of "Teacher I." With an initial F of 2.57 (analysis of variance), the means were corrected for differences in pre-math grade and resulted in the analysis of covariance below.

TABLE 12

Significance of the Mean Differences in Subjects' "Teacher I" Sort in June

Source of Variation	D.F.	Sum of Squares	Variance
Between	1	228.40	228.40
Within	54	2787.64	51.62
Total	55	3016.04	4.42 (F)

The F value in this analysis of covariance increases beyond the figure necessary for significance at the 5% level. It is of some interest to observe that no comparable difference is found in the mean scores of the control and experimental groups for the students' "Teacher II" sort (F = .20). It would appear that the expectations of Teacher I are judged differently and/or this teacher behaved differently in the conventional classroom under his exclusive management as contrasted to the experimental structure calling for shared control and some collaborative teaching with Teacher II. The latter, judging from the mean scores of the June sort, impressed the experimental students as relatively more demanding of them than Teacher I.* This apparent difference in the way in which students assess the expectations of a given teacher appears as a function of the systems context in which that teacher operates and is discussed further in the final chapter.

The fact that students in the control group had a significantly higher "teacher" sort in September (Table 11) may suggest one factor that led to a progressive increase in their mean "you" sorts from September to June (Table 9), a development that was not observed in the "you" sorts of the experimental group. It is reasonable to assume that if a student "sees" his teacher expecting more of him than he, the student, expects of himself, and if he regards the teacher as a significant adult authority, then, within limits, such a disparity would serve to push the student's "you" sort upward through time. This factor, as a potential source of upward mobility in the "you" sorts, was apparently absent from the data provided in the experimental class. Indeed their "teacher" sorts in September were slightly lower than their corresponding "you" sorts, 72.20 versus 73.35 respectively.

---

* Differing perceptions of the same teacher's expectations occurred also in School B where one of the two teachers was confronted by a similar discrepancy in the mean perceptions of his students in the experimental and control classes.

However, it should be noted that an increase of considerable magnitude characterized the mean "teacher" sorts of the experimental subjects, increasing from 72.20 in September to a high of 81.54 for "Teacher II" in June. Furthermore, though the mean difference in June favored the control group for the "Teacher I" sort, the size of the difference and the corresponding F ratios were considerably reduced over the period from September to June.

One reason for the strong indications in both "you" and "teacher" sorts favoring the control group in School A in the period of September to June is the fact that the experimental structure did not achieve orderly establishment here until well into December. Hence, teachers during the first part of the school year were likely handicapped to some extent in "communicating" their expectations to the experimental group. The eventual stabilization of the experimental structure made possible a substantial increase in the subjects' "teacher" sorts but likely came too late for this increase to affect the student's perception of his own responsibility. In the final analysis, one must recall that only minimal experimental conditions were instituted in School A; such limited institution of the structure cannot be expected to provide a valid basis for assessing the system. Furthermore, a variety of practical difficulties, largely extraneous to the experimental system, served to inject occasional uncertainty into the program, a condition more likely to affect dispositions and perceptions of both student and teacher than cognitive performance.

It is of some relevance to note that the results of the "did" sort in June (who did perform these tasks most frequently in the course) were congruent with the findings on cognitive performance -- no difference of any significance between the control and experimental groups.

TABLE 13

Mean Difference -- "Did" Sorts -- June - School A

Group	Mean Scores	F (df)
C	64.47	.13 (79)
E	65.02	

The comparative "did" sorts contrast with the corresponding "you" and "teacher" sorts. It is important, however, to note the qualitative difference in the sorting of tasks with normative or "ought" overtones and the more descriptive decision involved in identifying the agent(s) who "most often performed them." Also, the absence of a mean difference between the "did" sorts is not necessarily inconsistent with the comparative results of the "you" and "teacher" sorts. What students actually do reflect the daily priorities and practicabilities of school life to be depends on a complex of factors of which only one constituent is the student's perception of what his responsibility is or "ought to be" in engaging in teaching-learning processes. At the least, the student in the experimental program in School A apparently did not see himself performing less readily under the experimental structure than did his counterpart in the control class.

Operations Logged by the Teacher Assistant

It is of some importance to account for a variety of activities and operations performed by a number of agents in any "system" of instructional resources that exert mutually reciprocating effects upon each other. From the beginning of the year, teachers and teacher assistants recorded their daily activities so as to reflect changes in their engagements as a result of their participation in the experimental structure. A sample of such recorded activity by a teacher assistant is presented below. This period extended from March 7 to June 15, 1962 and represents 62 school days in School A.

TABLE 14

Teacher Assistant Log Record - School A
Number of Times Operations Recorded -- March 7 - June 15

Operation	Group Structure Total	Group Structure Subgroup
Administering and monitoring quiz	1	22
Applying discriminating criteria, forming subgroups, clerical tasks, records, attendance	51	
Laboratory supervision	1	8
Marking tests & recording grades	38	
Projecting films and slide-tapes	13	15

It was decided that one of the advantages of the experimental structure would be the increased opportunity provided the staff, the two teachers, to engage in activities of a higher professional order. It was immediately recognized that there would be two prime sources of such opportunity emanating from the structure -- time made available through teacher collaboration and time made available through the complementary use of audio-visual media. Theoretically, on those occasions when one teacher had the responsibility for providing instruction for the whole group, the other collaborating teacher could give attention to other concerns involving the management of subsequent classroom instruction. Similarly, as films and slide-tapes were projected in the whole group by the teacher assistant, time thus made available would accrue to both teachers who would be in a position to engage themselves in other tasks.

Since School A did not institute the dimension of teacher collaboration in a comprehensive way, the teachers did not realize additional and new opportunities through this set of operations. The only source of new opportunity was the complementary use of audio-visual media, and the potential number of combined hours thus made available to the two teachers is represented in the table below.

TABLE 15

Deployable Time Available through Complementary Use of Media
(March 7 to June 15, 1962)

Total Group Class Instruction	Subgroup Instruction
$\frac{13 \times 22 \times 2}{60} = 9.5$ hrs.	$\frac{15 \times 22}{60} = 5.5$ hrs.

In instances where films and filmstrips were used for total class instruction, the number of such occasions was multiplied by 22 (the average length of the films and filmstrips used in the course), times 2 (two teachers), and divided by 60 to result in 9.5 man-hours of deployable time made available through the complementary use of media in instruction. Where films and filmstrips were used in subgroup instruction, a similar calculation leads to a figure of 5.5 man-hours, an amount much less than the time involving total instruction since it must be assumed that only one teacher would be so engaged in providing instruction to a subgroup. In any event, in the course of this period of school days, the use of films and slide-tapes provided the two teachers with an additional fifteen hours of school time to use in ways other than direct classroom teaching that would normally have been demanded of them in the conventional situation.

It should be noted that the teacher assistant provided additional opportunities for such deployment of professional time of teachers, particularly in cases where she marked tests and recorded grades and provided numerous other services of a clerical and supervisory nature. These tasks would invariably have occupied both teachers in the usual situation. The value of a teacher assistant performing such non-professional tasks has been proclaimed for some time. In the occasional instance, schools have provided teachers with such assistance.

SCHOOL B

In contrast to School A, School B provided an opportunity to introduce a number of variants of the initial experimental structure in order to compare the relative effectiveness of its modifications in stipulated ways. This school made available a total of eight physics sections taught by two physics teachers. Four of these sections comprised the control group which was taught in a conventional way with two sections assigned to each of the two teachers and managed autonomously. The first experimental cell, EI, was comprised of two regular physics classes with a total of 48 students; the second experimental cell, EII, was similarly composed of two sections totaling 40 students. Both experimental groups were taught through the combined efforts of the two teachers with one important variation -- the fourth dimension, free access to the school's resources, was not part of the experimental structure in EI but was represented in EII in combination with the first three dimensions. As was pointed out in the chapter on Procedures, the control cell contained two select classes of "accelerated" students which were taught by Teacher I. The other two classes in the control cell, which consisted of 76 students, were composed of "regular" students and were taught by Teacher II in the conventional way. In both experimental cells the students were classified as "regular."

Comparison Between C, EI, and EII Groups on Independent Variables

The following table contains the group means for mental age, pre-math grade, pre-science grade and vocation for each of the three cells in the design.

TABLE 16

Group Means on Independent Variables

Group	Mental Age	Pre-Math Grade	Pre-Science Grade	Vocation
C (N=76)	227.51	30.14	29.96	.63
EI (N=48)	222.37	26.08	23.25	.77
EII (N=40)	217.47	25.75	28.30	.85

In the comparison of C versus EI, mean differences in pre-science and pre-math grades were large enough to be significant at the 5% level in favor of the control class. In the comparison between the control and EII cells the differences in mental age and pre-math grades were large enough to be significant at the 5% level. In these instances, the differences favored the control cell. In comparing EII and EI cells, only the pre-science grade difference turned out to be significant in favor of EII. However, these differences in independent variables among the groups were noted to have varying influence on subsequent analyses of covariance among the dependent variables and, as was the case in School A, mental age and, particularly, pre-math grade differences were instrumental in causing considerable shifts or modifications in the F values within the comparisons. Hence, the results reported below will reflect analyses of covariance and the corresponding adjustments due to differences in mental age and/or pre-math grades among the comparison groups.

Dependent Variables

As in the case of School A, the experiment in School B provided data of four types: (1) achievement as demonstrated by students in their command over subject matter content and in problem solving skill and reflected in a gain score obtained by subtracting pre-test from post-test scores for each student; (2) changes in attitude to the scientist, scientific method, and science-society interrelationships as obtained through a pre- and post-administration of the attitude instrument; (3) the assessment of the physics course in relation to their evaluation of other courses as obtained from the students through the Student Opinion Survey instrument; (4) changes in the perception of the students of tasks involved in the teaching-learning process and the appropriate agent or agents expected to perform them as obtained through the administration of a Q-sort instrument three times during the year. In addition, subscores were computed on all four of these dependent variables and their reporting will be done below in instanceswhere important differences appear in the comparisons between the control and the experimental groups.

(1) Cognitive Achievement. The mean gain scores obtained by the control and experimental groups and their respective standard deviations are contained in Table 17 below.

TABLE 17

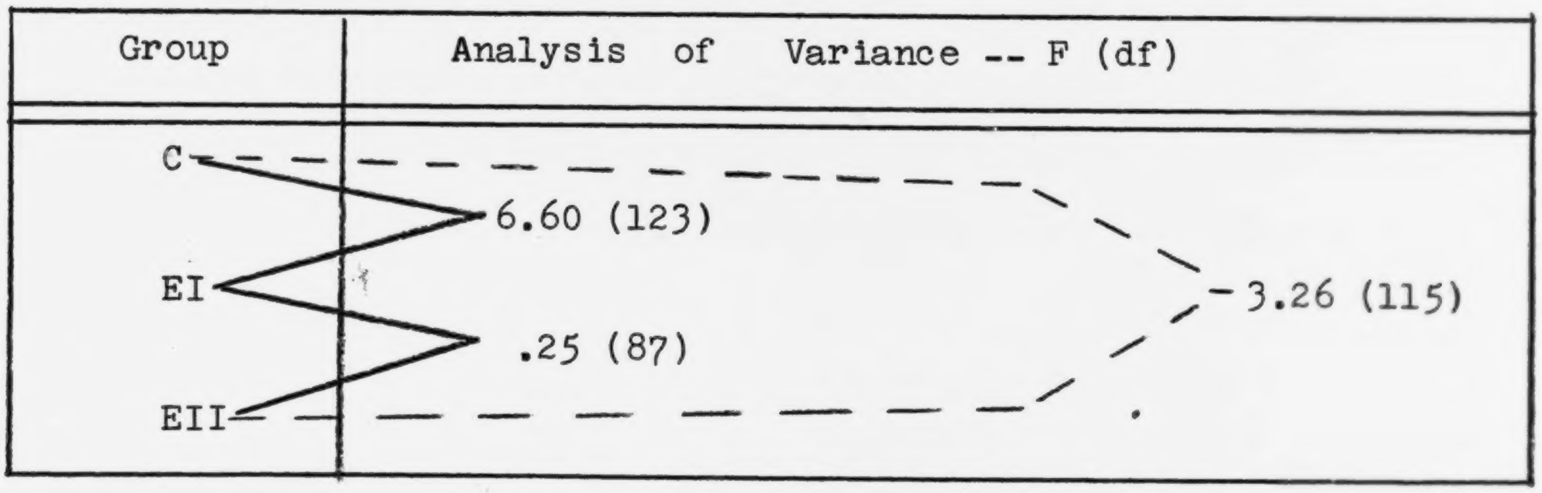
Mean Gain Scores -- Groups C, EI, EII

Groups	Mean Gain Scores	Standard Deviations
$C_{(N = 76)}$	20.03	6.611
$EI_{(N = 48)}$	17.08	5.588
$EII_{(N = 40)}$	17.72	6.448

It will be noticed that the control group obtained a mean gain score considerably in excess of the corresponding scores obtained by the Experimental I and Experimental II groups. In examining the significance of the differences between the three comparison groups -- C versus EI, C versus EII, and EI versus EII -- it will be seen in the table below that only the difference between C and EI becomes significant beyond the 5% level with an F ratio of 6.60 and 123 df in the analysis of variance.

TABLE 18

Mean Differences -- Gain Scores -- C, EI, EII



The mean difference between the C and EII groups produced an F of 3.26 which is slightly below the value significant at the 5% level (3.94 with 100 df). The F ratio for the mean difference of the EI and EII comparison is not significant.

When the mean gain scores were corrected for differences in pre-math grade between control and experimental I groups, the following results were obtained in analysis of covariance.

TABLE 19

Significance of Difference -- Mean Gain Scores -- C vs. EI

Source of Variation	df	Sum of Squares	Variance
Between	1	68.29	68.29
Within	121	3720.44	30.74
Total	122	3788.73	2.22 (F)

The F value becomes reduced to 2.22 and is significant at considerably below the 5% level, but the mean difference remains in favor of the control group. An attempt was made to identify the origin of the difference in the gain score among the lower and higher mental processes. Table 20 indicates the significance of the mean gain scores on the lower mental processes subscore between control and EI groups.

TABLE 20

Significance of Difference -- Mean Gain Subscores (LMP) -- C vs EI

Group	Mean Subscore LMP	Analysis of Variance - F(df)	F corrected for Pre-Math Grade (df)
C	10.98	7.88 (123)*	3.75 (122)
EI	8.64		

* Significant at the 1% level.

Analysis of variance produced an F value of 7.88 at 123 df which was reduced to 3.75 when corrected for pre-math grade difference. At the latter F value, the difference becomes significant at slightly below the 5% level. Nevertheless, the substantial mean difference in gain scores between C and EI groups was a likely outgrowth of the large difference in the lower rather than the higher mental processes subscore.

A similar comparison in mean gain scores between control and EII groups produced an F value of .54 with 114 df.

TABLE 21

Significance of Difference -- Mean Gain Scores -- C vs EII

Source of Variance	df	Sum of Squares	Variance
Between	1	18.05	18.05
Within	113	3734.62	33.04
Total	114	3752.68	.54 (F)

This F value is a result of analysis of covariance when adjustment is made for difference in pre-math grades between the two groups. The resulting comparison leads to the conclusion that no mean difference of any significance was observed in the gain scores between the control and EII groups.

(2) Attitude to the Field of Science. Pre- and post-administrations (I and II respectively) of the attitude instrument were given to the three groups in School B and the resulting mean scores and their corresponding standard deviations are shown in Table 22 below.

TABLE 22

Mean Scores -- Pre and Post Attitude Scores (I and II) - C,EI,EII

Group	Mean Scores		Standard Deviation	
	I	II	I	II
$C_{(N = 76)}$	220.65	216.82	14.140	18.168
$E\ I_{(N = 40)}$	213.45	208.91	33.692	23.897
$E\ II_{(N = 48)}$	224.87	218.45	13.044	12.351

An assessment of the significance of the mean differences in both the pre- and post-administrations between the three comparison groups -- C vs. EI, C vs. EII, and EI vs. EII, is contained in Table 23.

TABLE 23

Significance of Mean Difference -- Science Attitude I and II

Comparison Groups	I	II
C vs. EI	2.72 (123)	4.35 (123)*
C vs. EII	2.45 (115)	.25 (115)
EI vs. EII	4.08 (87)*	5.20 (87)*

* Significant beyond 5% level (3.78 at 70 df).
C vs. EI in favor of C.
EI vs. EII in favor of EII.

This representation of the results is prompted by the desire to reflect important differences quickly. The significance of the differences in the overall mean scores of the three comparison groups when corrected for differences in pre-math grade is represented in Table 24 which reveals three F ratios that are significant beyond the 5% level in favor of the experimental group EII when compared to the C and EI groups.

TABLE 24

Significance of Mean Differences -- Corrected for Differences in Pre-Math Grade -- F(df)

Comparison Groups	I	II
C vs EI	1.80(122)	1.72(122)
C vs EII	4.06(114)*	1.79(114)
EI vs EII	4.12(86)*	5.75(86)*

* Significant beyond the 5% level in favor of EII (3.98 at 70 df)

The EII group began at the beginning of the year with a significantly higher mean score on the attitude instrument when compared to the control and EI groups. At the end of the year, however, this relative superiority declined in comparison to the control group but was maintained when compared with the mean score of the EI group. In an attempt to identify the sub-topics that may have been instrumental in producing these differences within the comparisons, the mean subscores of all the comparison groups were classified and placed in the table below.

TABLE 25

Significance of Mean Differences

Pre and Post-Science Attitude Subscores

Comparison Groups	Method of Science		Scientist		Science-Society	
	I	II	I	II	I	II
C vs. EI (df = 117)	.08	2.29	1.54	.47	2.19	1.36
C vs. EII (df = 108)	1.07	.21	1.45	1.92	5.49*	1.24
EI vs. EII (df = 81)	.27	4.05*	4.26*	5.37*	10.94*	4.85*

* Significant beyond the 5% level (3.78 at 70 df) in favor of EII.

When adjustments in these mean subscores were made for differences in pre-math grade, it was observed that the superior performance of EII over C in administration I originated largely in the "science-society" subscore. The decline of the significance in the total attitude mean difference (F - 4.06 to 1.79) is also reflected in a shift in the responses of the EII subjects to the items in the same subscore category. A similar decline occurred in the comparison between EI and EII when the F value decreased from 10.94 in September to 4.85 in June, but still remained significant beyond the 5% level.

It is of special interest, however, to note the shifts in subscores dealing with method of science and the scientist in favor of EII when compared to the scores of EI subjects. Between September and June, the F value for method of science and scientist subscores increased to significant 4.05 and 5.37 F values correspondingly. Evidently, the opinions of students on matters relating science and society changed in the negative direction within the year, but their judgments on the other two subscores in comparison to the EI group moved in a positive direction. In comparing the mean subscores for the control and EII groups on the scientist, the initial superiority of the EII responses was slightly increased by raising the F value from 1.45 to 1.92 in the June administration. While both of these values are not significant, the direction in the responses of the EII subjects on the subscore of the scientist is consistent with the corresponding comparison with EI results.

In general, the comparative results on this instrument for the total and subscore comparisons appear to produce the same pattern within the data as did the results on the achievement tests, with the control groups generally showing a superior performance over the EI subjects, while the EII subjects did usually as well as the control group and showed instances of superior performance over EI.

The tendency for the mean scores for all of the comparison groups to decline between September and June is observed and further discussed in a section on general assessment in the following chapter.

(3) Student Opinion Survey -- Course Assessment. A similar tendency in favor of the control group over the Experimental Group I (with the EII subjects performing in the interval) is reflected in the mean scores obtained through the two administrations of the Student Opinion Survey in January and in June, in which subjects rated and ranked their physics course in relation to their other courses. The mean scores for the three comparison groups and their corresponding standard deviations are contained in Table 26 below.

TABLE 26

Mean Scores -- SOS January (I) and June (II) -- C, EI, EII.

Group	Mean Scores		Standard Deviations	
	I	II	I	II
C	134.06	126.31	28.988	33.584
EI	123.31	112.66	26.331	34.806
EII	129.77	116.80	20.259	28.461

When the significance of these differences was determined by analysis of variance and adjusted for differences in pre-math grade through analysis of covariance, the F values obtained for the three comparison group combinations were as follows.

TABLE 27

Significance of Mean Differences -- SOS I and II

Comparison Group	Analysis of Variance F(df)		Covariance Analysis (Pre-Math Grade) F(df)	
	I	II	I	II
C vs. EI	4.34(df = 123)	4.72	1.60(df = 122)	2.51
C vs. EII	.69(df = 115)	2.32	.01(df = 114)	1.03
EI vs. EII	1.61(df = 87)	.36	1.67(df = 86)	.36

It will be noted that when the ratings of the EI and EII groups were adjusted for differences prevailing in previous math grades, the F values in the comparisons between the Control versus EII and EI versus EII groups were located at levels that can be regarded as reflecting differences due to chance. Only in the comparison of C versus EI does the F value remain at a fairly substantial level of 2.51, though still below the level of significance at the 5% level. However, as in the history of attitude scores, a decline in the mean ratings is observed for all of the three groups between the first and second administrations.

(4) Q-Sort Data. Students in all three comparison groups were asked to sort a set of tasks in teaching-learning activities three times throughout the year -- in September, January, and June -- as to who was primarily responsible for the performance of those tasks. A higher mean score reflects a recognition of increased responsibility accruing to the student as against the other agent, the teacher. The table below contains the mean scores for the "You" sorts obtained by the three groups in the course of the three administrations during the year.

TABLE 28

Mean Scores -- "You" Sorts

September (I), January (II), and June (III)

Group	I	II	III
$C_{(N = 76)}$	75.02	76.31	76.22
$EI_{(N = 48)}$	73.43	74.33	73.68
$EII_{(N = 40)}$	73.82	76.37	76.07

It will be noted that in September (I) the control groups obtained a mean score of 75.02, greater than the mean scores for the two experimental groups. This is to have been expected in that the control groups included the two "accelerated" classes of students in physics. It is noteworthy, however, to observe that in the course of the year the EII group approximated the mean scores of the C group, obtaining 76.37 and 76.07 respectively in January and in June in comparison to 76.31 and 76.22 for the C group. The EI group (that was deprived of "free access to the school's resources") reflected little or no change over the year in their mean sorts.

A table containing the F values for analysis of variance and the corresponding values obtained through covariance when correction was made for differences in pre-math grade is below.

TABLE 29

Significance of Mean Differences -- "You" Sorts I, II, III

Comparison Groups	Analysis of Variance F(df)			Covariance Analysis F(df)		
	I	II	III	I	II	III
C vs EI	2.20 (df=123)	3.33	4.81*	1.49 (df=122)	1.60	2.73
C vs EII	1.12 (df=115)	.00	.01	.98 (df=114)	.33	.00
EI vs EII	.15 (df=87)	3.45	3.14	.14 (df=86)	3.76	3.14

* Significant at the 5% level (3.98 with 70 df) in favor of C.

In these comparisons, the control group gave evidence of better performance by obtaining F values of a progressively greater order in comparison to the EI results. On the other hand, the initial differences in favor of the control group were obviated by mean increments in the "You" sorts of EII subjects throughout the year to result in an F value of .00. In contrast, and again consistent with the results from other instruments, the EII subjects reflected a superiority over EI in their "you" sorts throughout the year, though the final F value of 3.14 is not large enough to be significant at the 5% level. It is of interest to note that when the differences in mental age were used to adjust the results obtained in the EI versus EII comparison, the F value in the second administration, in January, was increased to 4.64 in favor of the EII group, which is significant beyond the 5% level with 70 df. Similarly, the F value of 3.14 in the third administration increased to 3.67, also in favor of the EII group, but below the level of significance at 5%.

To point up the areas in which changes were more pronounced throughout the year, the "you" sort total scores were divided into their subscores dealing with tasks involving (1) evaluation of the students' general performance, (2) inquiry or problem solving procedures, and (3) various forms of learning activities. Table 30 below contains the F values for differences in the mean subscores between the comparison groups throughout the three Q-sort administrations - September (I), January (II), and June (III).

TABLE 30

Significance of Mean Differences - "You" Sort Subscores I, II, III

Comparison Groups	Evaluation			Inquiry			Learning Experiences		
	I	II	III	I	II	III	I	II	III
C vs. EI (df=122)	.16	.57	1.19	2.69	1.40	1.31	.41	.73	2.00
C vs. EII (df=114)	.11	.05	1.98	.13	.61	.63	3.40	.04	.23
EI vs. EII (df=86)	.37	1.18	.02	1.78	3.49	4.69*	1.61	1.07	3.10

* Significant beyond 5% level (3.98 with 70 df)

These F values have been corrected through an adjustment for differences in pre-math grade and reveal some interesting changes within the subscore categories over the year. Again, when the control group group is compared with the EI group, the increasing F ratios for all of these subscore categories throughout the three administrations are in favor of the control group. Though they are not at a level considered significant, the pattern tending to favor the control group is suggestive of relative superiority of the conventional format of instruction in affecting the perceptions of students. When the EII subjects' sorts are compared to those of the control group, it is noted that a mean difference in sub-category "Learning Experiences" in September (I), with an F value of 3.40 in favor of the control group, was more than made up during the course of the year by the EII subjects with the resulting F value of .23 and a mean difference slightly in favor of the EII group but not large enough to be significant at the minimal 5% level. Similarly, in the comparison with EI, the EII subscores difference grew to significant proportions (at 5%) in the sub-category of "Inquiry or Problem Solving" with an F value of 4.69 in the June administration. Similarly, in the sub-category of "Learning Experiences," the F value of 1.01 in September rose to 3.10 in June and reflects an increment in the mean score of the EII group that begins to approach the magnitude necessary for significance at the 5% level. It would appear that students in the Experimental II group, with the benefit of all four dimensions composing the experimental structure, were exposed to the kinds of influences that reflected particularly on the way in which they perceived their own responsibility in engaging in tasks involving

Problem Solving and pursuing Learning Experiences.

In addition to the "you" sorts, the subjects were asked to sort these tasks as they thought the "teacher" would sort them. In effect, the students gave their own perceptions of what they saw their teacher(s) expecting of them. Table 31 contains the mean scores of the "teacher" sorts of the three groups in September, January, and June. It will be noted that in the June administration, the students were asked to sort the tasks separately for both teachers, TI and TII, in the two experimental groups. Also, the classes in the control group sorted the tasks according to the teacher, TI or TII, who taught them during the year, hence, the different N's in sort III under the columns TI and TII.

TABLE 31

Mean Scores -- "Teacher" Sorts -- I, II, III

Group	I	II	III	
			TI	TII
C (N = 76)	75.21	74.97	76.31 (N = 29)	78.61 (N = 47)
E I (N = 48)	73.81	75.66	73.12	78.35
E II (N = 40)	75.12	77.22	74.47	81.12

Gradual changes in the mean scores within groups and between groups can be seen throughout the three administrations. In September, the control group obtained a mean sort that is approximately the same as that of the mean sort of EII. EI subjects, however, produced a mean score somewhat less than that of the other two groups. In January, it is of considerable interest to note, the mean sort of the control groups declined somewhat from that in September, while the mean sorts in both EI and EII increased over their September scores. In June, the data in EI and EII reveal the phenomenon of a differential assessment of one teacher over another as perceived by the same group of students when the two teachers were functioning in a collaborative relationship. Teacher I obtained a mean sort in both EI and EII considerably below the corresponding mean sort assigned to Teacher II by the same two groups. It will be remembered that this same phenomenon was observed in School A when one teacher, Teacher I, similarly impressed the experimental subjects as being somewhat less demanding of them than Teacher II when both teachers were seen in juxtaposition in the experimental structure. Significance of these differences is noted in Table 32 below in which F values are provided through analysis of variance between the three comparison groups.

TABLE 32

Significance of Differences - "Teacher" Sorts I, II, III

Comparison Groups	I	II	III	
			TI	TII
C vs EI (df = 123)	1.25	.39	4.54* (df=76)	.02 (df=94)
C vs EII (df = 115)	.00	2.76	1.20 (df=68)	1.67 (df=86)
EI vs EII (df = 87)	.88	1.27	.83	2.17

* Significant beyond 5% level

The only F value that becomes significant (beyond the 5% level) is that represented in the comparison between the Control and EI groups in the June sort for Teacher I where an F value of 4.54 was obtained. While no other F values approach significant levels, it is important to observe that the differences involving the EII experimental group tend to favor this group when compared with the comparable "teacher" sorts for Control and EI subjects. The exception is the June sort (III) for Teacher I in which the control classes judged him as somewhat more demanding and expecting greater student responsibility than did the subjects in EII. Nevertheless, it should be observed that subjects in EII, who were exposed to the complete experimental structure including free access to the school's resources produced "teacher" sorts in January and in June for both teachers that reflected higher "teacher" demands and expectations of students than did the EI subjects (minus free access) for the same administrations.

It would appear that the increased interaction that prevailed throughout the year in the EII group with the two teachers apparently resulted in a tendency to note somewhat higher expectations from these teachers than was judged to be the case by the EI group for both teachers and by the control group for Teacher II.

The "teacher" sorts for all three administrationswere then grouped into the three sub-categories of tasks and similar comparisons were completed. In the table below a grouping of F values following correction for differences in pre-math grades is set up for the three sub-categories of evaluation, inquiry, and learning experiences for the three sorts throughout the year.

TABLE 33

Significance of Differences -- "Teacher" Sort

Subscores -- I, II, III

Comparison Groups	Evaluation				Inquiry				Learning Experiences			
	I	II	III**		I	II	III**		I	II	III**	
			TI	TII			TI	TII			TI	TII
C vs EI (df=122)	2.58	1.09	1.46	.01	.48	.05	1.38	1.68	.11	1.62	5.42*	.52
C vs EII (df=114)	.03	.39	.28	.35	.02	7.96*	.09	1.36	.53	1.62	3.93*	1.73
EI vs EII (df=86)	3.44	.07	.03	.45	.72	7.15	2.82	6.44*	.08	.04	.08	.57

** df for III C vs. EI: TI = 75, TII = 93; C vs. EII: TI = 67, TII = 85.

* Significant beyond the 5% level (F = 3.98 with 70 df)

Considerable increments in the "teacher" sorts for the sub-category of inquiry in the case of EII subjects led to significant F values between EI and EII and C and EII. The F values of 7.15 and 7.96 are significant beyond the 1% level.

Similarly, in the third administration in the same sub-category, EII subjects sorted Teacher II expectations higher than the Control and EI groups. While the F value of 1.36 in the Control versus EII comparison does not approach significance, the F value of 6.44 in the EI versus EII comparison is significant at a level approaching 1%. In the case of Teacher I, the teacher sorts for EII resulted in a mean score greater than that obtained by subjects in EI but at an F value of 2.82 which was not sufficient to prove significant at the 5% level.

It appears that in the experimental structure for both EI and EII groups, Teacher II appeared to communicate to the students a set of expectations that seemed to the students more demanding or of a higher order than did Teacher I. In the experimental situation, where the students were in a position to assess both teachers in juxtaposition to each other, Teacher I appeared to be somewhat less demanding of them than did Teacher II. Also, when comparisons are made between the assessments of their teachers by the control groups and the assessment of those same teachers by the EI and EII classes in the sub-category of learning experience, the Control classes of Teacher I saw significantly higher expectations of their "Teacher" than did both EI and EII groups, with F values of 5.42 and 3.93 respectively. These values are significant at and beyond the 5% level. Teacher I evidently succeeded in communicating a higher level of expectations to his control classes than he did in a collaborative arrangement with Teacher II to Experimental I and II classes. In the case of Teacher II, the Experimental II class regarded him as somewhat more demanding of the students than did his own conventional class sections. The difference between the scores, however, produced an F value of 1.73, which is not significant.

What differences occurred in the "Did" sort of the three groups in June? When the sorts of the Control and both Experimental classes were calculated, the results again showed the Control and EII classes to reveal similar assessments of the extent to which students actually "did" assume responsibility throughout the year. EI subjects had a mean score considerably lower than the scores obtained by the other two groups. Table 34 shows the means scores and corresponding standard deviations of the three groups' "Did" sorts in June.

TABLE 34

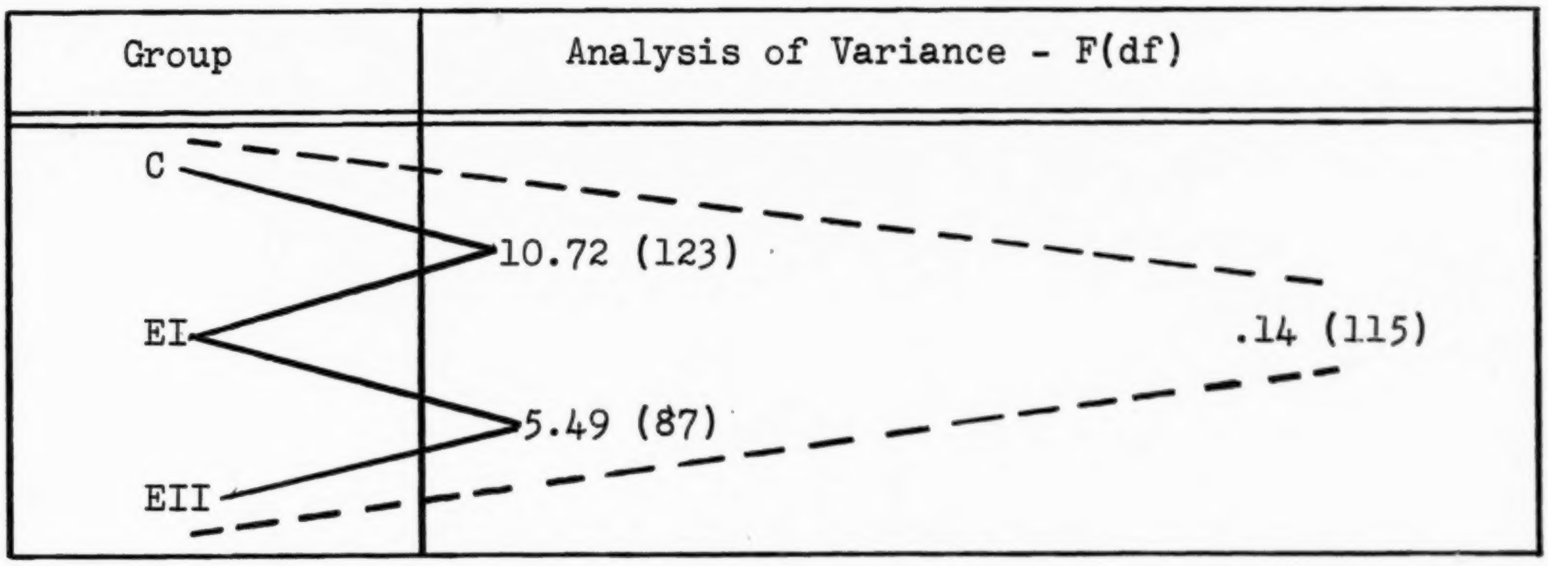
Mean Scores -- "Did" Sorts - June

Group	Mean Score	Standard Deviations
$C_{(N = 76)}$	65.81	7.396
$EI_{(N = 48)}$	61.04	8.661
$EII_{(N = 40)}$	65.25	8.043

When the significance of the differences between the three comparison groups was calculated, it was observed that the Control group demonstrated distinct superiority over EI (significant beyond the 1% level with an F value of 10.72); the EII group demonstrated comparable superiority over EI with an F value of 5.49 which is significant beyond the 5% level. A comparison of the C and EII groups produced differences of no significance.

TABLE 35

Significance of Differences -- "Did" Sorts -- June



In an attempt to identify, once again, the sub-categories in which these differences predominated, computations were made of the F values between differences of the three comparison groups for the three categories of tasks. It should be remembered that the "did" sort was administered only in June.

TABLE 36

Significance of Differences -- "Did" Sort -- III

Subscores

(F values adjusted for Pre-Math Grade)

Comparison Groups	Evaluation	Inquiry	Learning Experience
C vs EI (df = 122)	4.48*	7.72**	4.95*
C vs EII (df = 114)	.35	.08	.08
EI vs EII (df = 86)	2.63	5.81*	2.55

* Significant beyond 5%; ** beyond 1%

It will be noticed that differences with large F values of 7.72 in the case of C vs EI and 5.81 in the case of EI vs EII occurred in tasks relating to inquiry or problem solving. In addition, the comparison of C vs EI produced significant F values for the other two categories of evaluation and learning experiences, both in favor of the Control group. No difference in favor of the control group was evidenced in the comparison between C and EII in any of the three sub-category tasks. In the case of EI vs EII, the F value of 5.81 for the tasks of inquiry was the only value that was significant beyond the 5% level; the differences in the other two subscores were also in favor of the EII group but produced F values that fell short of significance at the 5% level.

Dimension 4 -- Free Access to the School's Resources

Another way to examine the effect of the fourth dimension on the instructional effectiveness of the system apart from the comparisons between group EII, EI (a modified version of the system minus free access), and the control group taught in conventional fashion is to examine the nature of the activities that are represented in the "free access" periods of one-half hour before the normal class period in EII. Each day, the teacher assistant listed every student who arrived for free access activity. The following table records the number of times the students listed themselves for "free access" and the kind of activity that was checked by the student as that in which he was engaged during the period.

TABLE 37

Cumulative "Free Access" Record -- EII (N=40)

January 18 - May 29 (90 School Days)

Activity	No. Times Listed
Reference Reading (Science Dept. books and periodicals)	673
Extra Labs	93
Make-up Labs	16
Slide-Tapes	7
Pre-Arranged Films	0
Other	260
Total	1,049

Average/day = 11 + students

It will be observed that most students listed themselves for reference reading in books and periodicals (such as the American Scientist and Science Education) -- all of which were available in the science department office and laboratory. It will be noted that relatively few students made use of the slide-tapes that were prepared and used in class instruction and no individuals had requested films for preview in this period. One reason for the latter condition is probably the fact that many films are one-half hour in length and would be difficult to show within the one-half hour free access period. Furthermore, one must raise the possibility that once the students saw the films in class, they would be inclined to judge a repeated viewing during such a free access period as not worth the time required. This lack of use of available instructional material under conditions of "free access" is consistent with the findings of other researchers who similarly found relatively little demand for extra-class use of instructional resources that were initially intended and used for class instruction. (11, 19).

The category "other" involved working on problems in the textbook and those assigned by teachers. Both extra labs and such problem work was often conducted by students in groups and aided by one of the two teachers who was frequently present during the free access periods.

In an attempt to determine the extent to which such engagement in free access was related to scores on the achievement test and other measures, the EII group was divided into "high free access" and "low free access" subgroups with a median of 17 appearances throughout the period of 90 school days. The total range in frequency of individual student appearances was 0 to 80. The total group of 40 students was then divided into two groups of 20 each and comparisons were made between the scores obtained by both subgroups of students on the instruments administered throughout the year.

One interesting finding appeared in the pre-test and the gain scores of both subgroups. When high free accessors (HFA) were compared with low free accessors (LFA) as to their pre-test and gain scores, the following results were observed:

TABLE 38

Significance of Differences - Achievement Tests

HFA vs LFA (EII)

Group	Pre-Test	Gain Score	Standard Deviations Pre-Test	Standard Deviations Gain Score
HFA	17.30	20.20	3.246	6.955
LFA	15.00	15.25	3.111	4.908
(df=39)	F=5.23*	F=6.76*		

* Significant beyond the 5% level.

Since there was no difference of any significance in pre-math grade between the groups (F=.28), analysis of variance was used to indicate the significance of the pre-test and gain score differences. It will be noticed that these differences in both pre-test and gain scores are significant at a level beyond 5%. Also, increases in the standard deviations for pre-test and gain score figures were much greater in the HFA group and thus reflected increased variability in the distribution of gain scores in the HFA group. Such increase in standard deviation suggests the possibility that engagement in free access activities leads to the more pronounced expression of individual student differences as these differences became manifest in real achievement. In any event, the HFA subgroup demonstrated superior performance in the pre-test and learned more throughout the year to produce significantly larger gain scores.

No appreciable differences in mean scores of both subgroups on the attitude instrument were observed in either the September or the June administrations. However, the HFA group rated the physics course significantly higher than did the LFA group with F values of 4.07 and 6.30 for SOS 1 and SOS 2 respectively. Engagement in such "free access" activity appears to be positively related to a more favorable assessment of the course as revealed by significant differences in the SOS scores in the January and June administrations.

With regard to the Q-sort data and the perceptions of the students of their role and of their teacher's expectations, it is interesting to observe that in September the HFA group revealed a "You" sort that was significantly below the "You" sort of the LFA group in the area of inquiry or problem solving tasks (F of 4.15 which is significant at the 5% level). At the end of the year, however, this apparent superiority on the part of the LFA group disappeared as the June differences in this subcategory resulted in an F value of .10. There was no important difference in the total "Did" sorts of the two subgroups and only a suggested superiority in the subcategory of inquiry tasks in the "Did" sorts with differences in favor of the HFA subgroup at an F value of 2.48 (below the 5% level of significance).

When one examines the total "You" sort scores for the HFA subgroup in September, January, and June, the mean increments throughout the three administrations in this subgroup do much to bring the scores of the EII group as a whole to a level comparable to that of the Control group and superior to that of the EI group. The growth in EII "You" sorts can be attributed largely to the increments obtained in the "You" sorts of the "high free access" group.

When the two subgroups' "Teacher" sorts throughout the year were analyzed, the tendency for class groups to demonstrate differences in the perception of the expectations of Teacher 1 and Teacher 2 is strongly marked by the different sortings of the HFA and LFA subgroups for both teachers. For Teacher 1, the HFA students obtained a "Teacher" sort mean of 72.95 in June while the LFA subgroup produced a mean of 76 for a similar sort of their perceptions of Teacher 1's expectations. For Teacher 2, the corresponding mean sorts for the two subgroups of HFA and LFA were 80.80 and 81.45 respectively. While the F values in analysis of variance proved to be not significant in both cases, the differences suggested, nevertheless, an examination of subcategory tasks. The category of inquiry or problem solving tasks again reveals significant differences in the scores of the subgroups. The table below shows the subscore means for Teacher 1 and Teacher 2 produced by the sorts of the HFA and LFA subgroups.

TABLE 39

Mean Subscores of HFA and LFA for Inquiry Tasks

"T1 and T2" Sorts - June

Groups	Inquiry Subcategory	
	T1	T2
HFA	21.30	23.30
LFA	23.30	24.00
	F=5.84*	F=.54

* Significant beyond 5% level

Students in the LFA category produced a mean subscore of 23.30, two points greater than the corresponding mean subscore of 21.30 by the HFA group for Teacher 1. This difference produced an F value of 5.84, significant beyond the 5% level. No significant difference in the mean scores for Teacher 2's expectations could be observed between these two subgroups. In the light of the discussion concerning different ways in which Teacher 1's expectations had been assessed in the EII, EI, and Control situations, it was expected that differences in the perception of the expectations of an individual teacher by these two subgroups would result. Since T2 was most often "available" in free access, different frequencies of contact with the two teachers appears to be one factor in producing such discrepancies in perception. The table above shows that exposure through contact with the two teachers in "free access" periods as experienced by the HFA subgroup served to "depress" relatively their assessment of Teacher 1's expectations when contrasted to the corresponding assessment of the LFA subgroup. Hence, the early discrepancy that was discovered in the "Teacher" sorts of EII, EI, and Control groups is further documented within similar scores of the HFA and LFA students in the EII experimental class.

Operational Effects of the Experimental Structure

One of the expectations entertained in implementing the experimental structure was the possibility of providing the teachers with a greater degree of latitude in introducing activities and engaging themselves in ways not normally feasible under conventional conditions. One type of operational effect that was foreseen was the possibility of providing the teachers with additional time that otherwise would not have been available to them in the typical class situation. Such "new" time was expected to result from the operation of two of the dimensions in the experimental structure: (1) time made available as a result of the collaborative efforts of two teachers assuming co-ordinate responsibility in implementing instruction; (2) time that results from the complementary use of audio-visual devices, namely, films and slide-tapes, that were employed in autonomous ways. The latter use of media was prescribed by the concept of complementary role of communications media in recognition of their capacity to store and disseminate instruction under specified teaching conditions without the presence of the professional teacher.

The table below records the number of hours that were thus made available for both teachers as a result of their engagement in the two experimental class situations EI and EII logged during the period of February 19 to May 29, 1962.

TABLE 40

Deployable Teacher Time and Origin (EI and EII)

(February 19 - May 29, 1962)

Source	Hours
Teacher Collaboration (T1 & T2)	109
Films & Slide-Tapes (Assistant projecting)	34
TOTAL	143
Average hours/day	2.1

The experimental structure employed in both experimental cells led to the "creation" of an additional 143 man-hours of time for the teachers during the school day. On the average, 2.1 hours per day were thus made deployable for other purposes. These hours were calculated from daily logs maintained by the two teachers which recorded their engagements. It should also be noted that this average of 2.1 hours per day of "additional" teacher time is the result of applying the experimental structure to only one-half of the total load of both teachers. The other half of the teachers' load (four normal class sections) were used as controls in the experiment in School B and were taught in conventional ways. If one calculates the hours per day that would potentially be available were the experimental structure applied to all of the teachers' sections, then one approaches the rather astonishing number of over four man-hours per day newly made available to the two teachers who would be so engaged.

A further analysis of the daily teacher logs permitted the identification of ways in which this additional time had been used by the teachers. The table below records the manner in which this deployable teacher time was used in the course of implementing instruction.

TABLE 41

Logged Use of Deployable Teacher Time (T1 + T2)

(February 19 - May 29, 1962)

Activity	Percent of Time
Preparation for future instruction	45%
Miscellaneous (conferences with students and project director, research, ordering materials, testing, grading, library reference, quiz, publicity, book survey, school business, test construction, logging, schedules, grade sheets and cards)	55%

According to the logs, 45% of this time was used by the teachers in preparation for formal instruction in the future. Additional time thus made available for preparation is considered a valuable attribute of the experimental structure in that the new physics program of the Physical Science Study Committee contains fairly complex experiments and class demonstrations that require a considerable amount of preparation on the part of the teacher. Furthermore, both teachers saw the "large class" as demanding more thorough preparation than is typically the case with "normal" class instruction.

The remainder of the time, 55%, was used in a variety of tasks that under usual conditions are performed, if at all, after classes at the end of a school day, in evenings or on week-ends. Such activities included conferences with students and project director, research, ordering materials, testing, grading, library reference, quiz, publicity, book survey, school business, test construction, logging, schedules, grade sheets and cards. In the opinion of the teachers, the opportunities provided by the experimental structure in thus making available additional time during the day enabled them to deal with many new tasks that resulted from the introduction of the experimental program and also permitted them to carry on and complete other projects that would likely not have been performed in the conventional setting. Hence, the increased latitude thus provided the teachers could be regarded as energy input into the instructional system, one of the more significant operational effects of the experimental structure. Indeed, the common criticism of teachers who are faced with the task of implementing daily instruction is clearly a critical shortage of time in which they can pursue new ideas, revise and devise new curriculum, and attempt to introduce what they may consider as improved teaching practices in the classroom.

This deployable time originated from two factors operant in the experimental situation -- the collaboration of two teachers and the avoidance of duplication and needless repetition in carrying on daily instructional activities, and also through the autonomous use of instructional films and slide-tapes. The greater part of such deployable time appeared as a result of teacher collaboration. Hence, schools that embark upon new ways of organizing teachers and class groups in current "team teaching" experiments can similarly expect to make available new opportunities during the school day for engaging teachers in tasks otherwise difficult, if not impossible, to perform. It should be emphasized, however, that the implementing of such collaborative teaching demands more systematic attention and thorough preparation on the part of all teachers so engaged. School administrators must take care to assure that such newly available time is deployed in ways that lead to the improvement of daily instructional activities.There may be a tendency for teachers so "freed" to be employed in other, perhaps "distant", aspects of the school program. In such an event, the class instruction of those teachers may reflect the effects of inadequate preparation and planning in the daily conduct of the course program.

The second operational effect observed in the teacher logs is the frequency with which the teachers in the experimental cells, EI and EII, were enabled to institute functional grouping of students in applying the third dimension of the experimental structure.

TABLE 42

Variable Class Structure -- (EI and EII)

(February 19 to May 29, 1962)

Functional Subgroupings	No. time periods
Test reviews, advanced experiments, problem-discussions, etc.	23

During the period of February 19 to May 29, 1962 the teachers recorded 23 time periods in which the experimental groups were sub-divided for specific teaching purposes. The most frequent purpose in subgrouping was the attempt to avoid excessive as well as deficient redundancy in group instruction, such as review of periodic tests, and the pursuit by selected students of more advanced problems and original experiments. On the average the teachers were enabled to subdivide the total class almost once per week during this time period. Such differentiated instruction did not necessarily endure for only one class period of time. Log recordings show that some subdivisions continued for three consecutive class periods in a given week.

The Participation of the Teacher Assistant

Reference was made in the above discussion of deployable teacher time to the direct participation of the teacher assistant in the experimental program. Below is a table that summarizes the manner and frequency with which the teacher assistant participated in the instructional program in the period January 18 to May 29, 1962.

TABLE 43

Operations Logged by Teacher Assistant in EI and EII

(January 18, 1962 - May 29, 1962)

Activity	No. Occasions	
Supervised laboratory	Whole Group	Sub-Group
	6	92
Projected films and slide-tapes	60	1
Administered and monitored quiz	14	3
Marked tests and recorded grades	26	
Applied discriminating criteria, formed subgroups, maintained records, etc.	50	

It will be seen that the teacher assistant participated extensively in the daily implementing of classroom activities. Extra opportunity open to the professional teachers to pursue a variety of tasks is, in part, due to the presence of the teacher assistant. Also, the teacher assistant recorded daily attendance at the beginning of each period and processed late-comers in the formal procedure of the school. This daily task usually consumes up to five minutes of every class period. The teachers in EI and EII were thus enabled to start teaching as soon as the period began. In addition, the teacher assistant supervised the activities of subgroups on numerous occasions throughout this period. Finally, the teacher assistant was responsible for the projecting of all films and slide-tapes in both formal group instruction as well as under condition of free access, the recording of student attendance in free access, and acting as a liaison between the two teachers themselves as well as between the teachers and the project director. All such procedural but nevertheless important details were attended to by the teacher assistant who gained early recognition as an essential member of the teacher group in the program.

A Significant, Though Tangential, Phenomenon.

In the course of analyzing the data, it was observed that a number of students in both control and experimental groups sorted their teaching-learning tasks in ways that produced higher "You" sorts than their respective "Teacher" sorts. It seemed that some students in the program appeared ready to demand more of themselves in assuming responsibility for their learning than they saw their teacher expecting of them. This group of students contrasted to another group who expressed what may be viewed as more typical perceptions -- their "You" sort scores were below their corresponding "Teacher" sort scores. Teachers may well expect students, in general, to see their teachers demanding more of them than they are ready to demand of themselves. Here, then, was a group of students who did not conform to such a behavior pattern. In the course of analysis their achievement record on pre-test and gain scores was observed and compared to that of the more "typical" students. The table below records the mean scores of both groups on the pre-test and gain score results as well as the respective standard deviations.

TABLE 44

Q-Sorts -- Y>T vs Y<T -- September (C and EII)

Group	Pre-Test	Gain Score	Standard Deviations	
			Pre-Test	Gain Score
Y>T (N=53)	17.56	18.63	3.780	5.486
Y<T (N=63)	16.03	19.80	3.015	7.439
(df=114)	F=5.91*	F=2.05		

* Significant beyond 5% level.

The Y>T group of students scored significantly higher on the pre-test than did the Y<T group in September. This difference in group scores is significant beyond the 5% level. However, the Y<T students obtained a mean gain score that was higher than that obtained by the Y>T students. While this difference favors the Y<T students, it produced an F ratio that only approaches significance at the 5% level. In any event, the post-test scores at the end of the year showed differences of no significance between these two groups. It would appear that the general instructional climate in the science program tended to serve better the student with the more "typical" expectations -- the one who sees the demands and expectations of teachers as exceeding those he holds for himself. This tendency is further evidenced in the greater disparity in the standard deviations of the pre-test and gain scores for this group. It would appear that the "atypical" student -- one who would so sort the teaching tasks as to give himself a greater amount of responsibility than he sees the teacher expecting of him -- and his individuality continued to be less well provided for in the

program of instruction that was implemented throughout the year.

These data serve to dramatize the dilemma of the school today, a dilemma that, in effect, does not allow for the atypicality of certain students. The more conventionally ordered student tends to learn better in an environment that remains better fitted to him.

This anlysis of achievement data was conducted for students grouped on the basis of their Q- sorts in September. When students were regrouped in a similar manner but on the basis of their "You" and "Teacher" sorts in June and their post-test scores compared, the mean score of the $Y>T$ group exceeded again the mean score of the $Y<T$ group, in this case by a mean difference of four points, 37 to 33 respectively. While time was not available to compute the significance of this difference, it is expected that a four point mean difference would probably approach, if not exceed, the 5% level. Though the composition of the September and June groupings differed, the particular relationship between differential "You" and "Teacher" sorts and performance on achievement tests on a given occasion appears to be sustained.

CHAPTER IV

Summary Review, Conclusions and Discussion, and Further Research

Summary Review

At a time when educators and laymen alike are seeking ways to strengthen the educational process, ambiguity surrounds the possible role and contribution of audio-visual media in helping to accomplish this goal. Research evidence of the teaching effectiveness of film and other media, meager as it is, is also indefinitive -- studies, with rare exceptions, consistently reveal "no significant differences" between experimental and control groups.

The need is not to determine whether audio-visual media such as film or televison can teach, but to discover patterns of effective use of media and ways to relate them instructionally to the other teaching resources of the school. It is suggested that audio-visual media in instruction will prove more éffective if their use is designed to function in the context of other key determinants represented in a basic system of four dimensions:

(1) Complementary Role of Media -- their role is seen as complementing rather than supplementing the human resources in the school's program. Two use formats are identified as "autonomous" and "functionally relevant". Films and specially prepared slide-tapes, when used in autonomous fashion, can assume the burden of instruction on selected occasions. Overhead projection and closed-circuit television, when used in "functionally relevant" ways, meet the unique communication demands of formal instruction.

(2) Teacher Collaboration -- two teachers collaborate continuously in implementing the instructional program. This collaboration includes modification of their traditional involvement in class activity.

(3) Variable Class Structure -- timely subgrouping is introduced as suggested by prevailing teaching objectives.

(4) Free Access -- increased opportunity to use instructional sources on the part of the student enables him to pursue independent study.

There is considerable need for research today in this type of exploration where a number of systems components are introduced in varying patterns in order to determine their relative effectiveness in facilitating the achievement of educational objectives.

This experiment was conducted on the high school level in physics. Two schools were selected that met minimal requirements for the implementation of the research. In School A two teachers taught a total of four class sections in physics; two of the four classes were the experimental group. In School B, the number of classes and teachers permitted the introduction of two variants of the experimental structure, I and II.

In School B both teachers, T1 and T2, taught two independent class sections in a conventional way and these four classes were grouped into the control category. The two experimental cells were composed of what normally would have been four class sections but which were divided into "large" class groupings, I and II. In Experimental I, three of the four dimensions were introduced -- complementary role of media, teacher collaboration, and variable class structure. In Experimental II, the entire configuration of four dimensions was introduced, including "free access" to the school's resources. The attempt here was to determine the extent to which the fourth dimension, free access, influenced the effectiveness of the experimental structure I.

Following a year of pre-planning activity with the teachers of the participating schools, the experiment was instituted at the beginning of the school year of 1961 and continued to the end of the school year, June, 1962.

Four types of dependent variableswere measured by the following instruments: pre- and post- achievement tests, attitude inventory, Q-sort instument, and student opinion survey. Independent variables were mental age, pre-math grade, pre-science grade, and future vocation. In addition to data obtained from students as described above, other data was collected throughout the year from teachers and teacher assistants through logs and daily records maintained of their own and student activity in "Free Access."

Conclusions and Discussion

Since the experimental structure was implemented only to a minimal degree in School A, as reported in the preceding chapter, the observations contained in this section derive largely from the experiences and findings in School B.

In assessing the results of this project, it is emphasized that an entire structure or configuration is being evaluated and not specific or atomistic components, except as EI and EII substructures were introduced to reveal the impact of the fourth dimension, free access to the school's resources. Such an assessment of a total structure or configuration within one year is subject to a number of vicissitudes. Nevertheless, the results lead to the following observations:

(1) Cognitive achievement as measured by traditional test instruments does not appear to be markedly affected by the three comparative structures, though there is a tendency for the Control group to produce superior results when compared to the minimal

experimental structure EI (minus free access). This finding is consistent with results of literally hundreds of other comparisons made in teaching methods or strategies involving audio-visual media during the past decade -- there is little likelihood of achieving measurable improvement on this criterion in gross comparisons of teaching method. Differences in cognitive achievement, as measured by existing instruments or instruments that may be devised in the future, will more likely occur when more specific relations are instituted associating expected terminal behavior with clearly identified teaching strategies on an operational level and combined with a relevant organizational structure in which some effective ordering of the component parts is being introduced.

(2) While the experimental structures did not prove superior in affecting cognitive learnings, neither did the structure nor its variant lead to any decline in cognitive learnings on the part of students subjected to it. One can expect that experimental structures involving the four dimensions can be introduced and manipulated without disadvantaging the students according to the traditional criteria that are used to measure their performance. A decision to employ such a structure can be made in terms of other criteria, particularly those of a non-cognitive and operational variety.

(3) In examining the effects of the structure and its variant, EI and EII, upon other forms of student behavior and learning, it is noted that the dimension free access has some influence on the total impact of the basic structure (four dimensions versus three dimensions). While differences fell short of statistical significance in the Student Opinion Survey and attitude measures, the EII results,

as a pattern, appeared superior on both measures to those of EI. The apparent decline from a pre-administration attitude measure of significant proportions (EII versus C) to one of no significant difference in June may be accounted for largely by the generally regressive trend of the scores between the pre- and the post-administrations for all groups of students regardless of their Control or Experimental categorization.

(4) Effects of free access upon changes in student behavior and learning is particularly noted when the "high free access" and "low free access" subgroups are compared on both cognitive and non-cognitive criteria. It was observed that those students with higher frequency attendance during the free access period scored better on pre- and post-achievement instruments. They came in with superior performance on the pre-test and also gained more on the post-test in comparison to the low free access students.

When their "You" sorts were examined throughout the three administrations, it was noted that the high free access student had a mean "You" sort of 72.85 in September and 76.15 in June, revealing an increment of 3.3 points. In contrast, the low free access students had a mean "You" sort of 74.80 and 76.00 in June, reflecting only a 1.2 increment over the period. The high free access students therefore showed a mean growth of almost three times that demonstrated by the low free access students over the same period of time. In the main, the over-all growth in the "You" sorts of subjects in Experimental II from 73.82 to 76.07 is due primarily to the relatively larger increment shown by those students who presented themselves most frequently in the free access period. It is reasonable to expect that, in devising and assessing total systems of inter-related components of a learning environment, opportunities provided by free access lead to material improvement in cognitive and non-cognitive behaviors for certain students.

It should be pointed out that, theoretically, educators and teachers cannot expect students to assume more responsibility for their own learning until the environment in which the students function provides them occasion for choice on their part. Such greater opportunity to choose a course of action was made available in the EII structure, (albeit in a limited form -- choice of remaining in the school library or electing to come to the science laboratory workroom for one-half hour a day before normal class time). Nevertheless, as a student confronts such a decision and chooses one course of action over another, he implicitly exercises more control over what he actually does during the school day and assumes, in effect, more responsibility for his learning. As more alternatives are made available to students, schools can legitimately expect more students to say as one did when he assessed his own progress in the course: he wasn't doing particularly well but suspects that it is his own fault.

(5) In devising new structures in which two teachers collaborate closely in the daily implementing of instruction, it is clear that either different teaching styles and/or frequency of contact with students will lead to differences in the way in which the students perceive and judge the individual teacher's expectations. Such differences in an experimental structure of the kind introduced in this project may lead to perceived teacher expectations that are

assessed as less demanding and of a lower order than similar assessments made by students in the Control situation with that same teacher. If a student's perception of a teacher's expectations influences the expectations he holds for himself, then such a relative diminution in the assessment of a teacher's expectations in the experimental structure may result in decreased effectiveness with which that particular teacher can relate to students and influence particularly their non-cognitive behavior. This tendency is of considerable relevance to current projects in "team teaching," an administrative innovation that has gained considerable popularity in schools at the present time.

On the other hand, if teachers do possess different "styles" of teaching, according to the findings of Herbert Thelen (20), then it is conceivable that a learning environment that brings students into contact with more than one teacher in a given course and, particularly, if such a contact is effected in part by student choice, those students may gravitate to the teacher whose "teaching style" seems to be more congruent and consistent with their own "style of learning." It may very well be that the HFA students in the project were those who found greater congruence and compatibility with the expectations and teaching style of T2 (who was most often present during the free access period). On the other hand, the low free access students may be those who did not discover such compatibility with T2 and therefore elected to participate in free access less frequently or not at all.

(6) One of the disconcerting findings of the project was the apparent "plateau" effect observed in the trend of "You" mean

scores for Control and Experimental classes. It would appear that after the end of the year in December, the environment effected no further increments in the "You" sorts during the rest of the school year. Whatever potential the school program had in changing the "You" sorts throughout the course of the year had already exhausted itself before the end of December. If this was so, then teachers who are concerned about the manner in which students perceive themselves and their role in learning need to institute continuing assessments and modifications in the ways in which they interact with students during the course of the year. On the other hand, it may be that the conditions of the times at which the "Q" sorts were given -- September, January, and June -- may have been such as to have produced this "plateau" effect in the "You" sorts.

(7) It is in the area of operational effects that the experimental structure and its variant produced marked results. Considerably greater opportunity accrued to teachers in the form of more school time as well as greater flexibility in teaching procedures under the experimental structure than would have been possible under conventional conditions. In addition, both teachers were able to assume prime responsibility at selected times during the year in providing instruction in those areas in which they had greater interest and/or competency. Furthermore, the greater ease with which both teachers, with the participation of the teacher assistant, could institute functional subgrouping activities provided the teachers with a greater sense of professional accomplishment. As efforts to improve instruction continue to be thwarted by time pressures confronting teachers and rigidities in conventional

structures that prevent ready adaptation of teaching practice to the learning requirements in the immediate situation, the basic experimental structure introduced in this research project holds considerable promise in removing these practical obstacles.

However, a number of cautions are in order and emerge out of the year's experiment:

(1) While the experimental structure enables teachers to enjoy and realize greater freedom than is characteristic of conventional conditions, both teachers nevertheless must subject themselves to closer and tighter organization. Teacher collaboration, in an attempt to mediate more effective learning activities for a group of students, must be more highly structured: each teacher is no longer an agent autonomous, independent and responsible unto himself alone. Such subjugation to the need for more distinct organization and a commitment to a plan of action once elected may lead to a feeling of construction on the part of the teacher who attempts "to play it by ear" and habitually develops emergent teaching patterns and activities as he goes along.

(2) In an experimental configuration in which educational media provide core instruction on selected occasions, it must be recognized that such media as film and slide-tapes lead to more rigid modes of transaction in the communication process. Films and slide-tapes, as in the case of textbooks and laboratory guides, are forms of standardized message input and, at least for the time such one-way communication is in effect, they do not permit correction on the basis of continuing feedback from the learner-receiver. The communication chain that is created by film or slide-

tape instruction is more rigid because the "source" and "receiver" are more "distant", psychologically, from each other. Unless instruction mediated by such devices is complemented with other less standardized, more open interactions of a face-to-face variety with other agents in the environment, then it is not likely that the entire system will succeed in affecting cognitive achievement and student perceptions and commitment in a desirable direction. In other words, the strength of this experimental structure lies in its total impact, a structure in which each basic dimension can support and augment the effectiveness of others in the system. This is particularly true in the case of the third dimension, variable class structure, through which differentiated instruction can be implemented. In addition, personalized interaction between teacher and student is also facilitated potentially by "free access."

(3) It must be observed that change in the way students perceive themselves and their role in learning is a product of the entire school environment and a composite result of experiences in all courses and interactions with teachers. It is somewhat presumptuous to expect student perceptions to be significantly influenced by manipulating, at most, only one-fourth of the student's day in school. If the student spends the remainder of his time, a much larger proportion of his school day, in environments that are more traditional and conventional in character, then one can expect a neutralizing effect from those conditions in which teachers continue to dominate instruction and students exercise little choice in directing learning activities. As schools introduce greater opportunity for students to select the substance and direction of

learning and the occasion of their engagements, one can expect a greater overall impact as the student encounters repeated and similar expectations and opportunities at various junctures in the school's program when he moves from one area, course, and teacher to another.

(4) One of the major difficulties encountered by the teachers in implementing the experimental project was the fact that their managing of control and experimental strategies compelled them to carry out separate preparations and two different formats of teaching. They found this commitment to the experimental design particularly burdensome and, in their opinion, no mean factor in preventing the fullest exploitation of the opportunities provided by the experimental system. This condition was taken into account when, after three months of the experimental program, the teachers in School B noted the utility of the new procedures and decided to apply the experimental structure to all of their physics sections during the following year (1962-63). Such application of the program to all of their classes, it was felt, would enable them to gain greater advantage from the major dimensions of the system.

Further Research

This first year's project gave rise to a number of questions which are worthy of examination in subsequent research:

(1) To what extent are increased familiarity and competence in applying the experimental procedures and the elimination of "double" preparations related to improved effectiveness of the new teaching structure as the system is introduced to all classes taught by the teachers? Teacher familiarily and competence are no mean factors in the introduction of new methods -- the innovations usually

suffers the effects of novelty and uncertainty while the conventional procedures, as controls, are comfortably established in the repertoire of teaching skills through years of practice and experience.

(2) Do the "accelerated" students derive greater advantage from engagement in the new program when compared with the performance of "regular" students taught similarly by the experimental system?

(3) How do varied combinations of teachers in collaboration "teams" affect student learning (cognitive), the student's perception of his role, his assessment of the individual teacher's expectations, and his evaluation of the physics course? Some evidence in the first year revealed sharp differences in the way students in the experimental class (teacher collaboration) and those in the control classes judged the same teacher's expectations.

(4) In implementing the third dimension, variable class structure, in the first year's program, the question was raised regarding the utility of different procedures. The teachers devised three techniques that were intended to create those subgroups from the total class unit that would facilitate differentiated instruction throughout the year. The procedures had to be valid and easy to administer on a daily or weekly basis. The following bases were established and used: (a) a fairly stable division of the class unit into "upper" and "lower" subgroups (approximately 35% and 65% respectively) based on mid-semester and semester tests; (b) performance on a short three-to-five item quiz following a major topical presentation by teacher, film, or slide-tape to the class unit; (c) a voluntary self-assessment on the part of the student as to whether he felt that he had adequate grasp and understanding of the

content or whether he felt he needed more elaboration and assistance. The teachers used all three procedures at different times throughout the year. The question is, how valid are these procedures as means for determining subgroups and differentiating instruction?

(5) To what extent is the fourth dimension, free access to the learning resources in the school, instrumental in fostering changes in cognitive and non-cognitive behavior of students? Such accessibility, particularly to films and tape recordings, has been found to be of questionable utility in comparable projects (9) (12). However, the judgment of participating teachers and some of the non-cognitive data tend to support such a provision in a program. The question remains high-lighted by the current emphasis in new programs upon increased accessibility to a school's resources to promote individual learning activities.

(6) What use as a diagnostic device is promised by the Q-sort instrument as a basis for predicting the capacity and readiness of students for individual and independent work? Of particular interest is one relationship between the student's own and "Teacher" sorts and concurrent achievement. It appeared, for instance, that students who scored higher on "You" sorts (whose job would you say it is to . . .) than on their corresponding "Teacher" sorts (whose job do you think the teacher would say it is to . . .) performed significantly higher on the achievement pre-test given concurrently than did the students whose "You" sorts were lower than their corresponding "Teacher" sorts. This relative superiority on the pre-test in achievement, however, was not evidenced on the post-test. Should the diagnostic utility of this comparative sorting be of

questionable value over time in predicting cognitive superiority, might not the data of the Q-sorts of students nevertheless prove useful in composing a stable subgroup that could be brought into play whenever individual commitment and affective readiness may be more requisite than cognitive superiority in the successful conduct of a given activity? For instance, a high "You" sort subgroup might be given the opportunity to conduct a particular demonstration-experiment in the laboratory while the dependent group (lower "You" sorts) observe the same or similar experiment by the live teacher or surrogate instructor in a film of the PSSC series.

(7) Is a levelling off (or even a slight regression) in the mean scores of the "You" sorts throughout a school year to be viewed as a fairly reliable occurrence? Increases in the "You" sorts of the students were recorded between their September and January sorts. In June, however, the third administration showed no improvements, even fractional declines when compared to the January mean scores. If one assumes that the instrument has the potential to record and register further gains in the "You" sorts well above the January means of 76.31, 74.33, and 76.37 for the Control, Experimental I, and Experimental II classes respectively (corresponding standard deviations were 6.661, 4.372, and 5.925), then the question arises at to whether the potential power of the teaching method in evoking further perceptual change in the positive direction had exhausted itself within the first few months of instruction following the inception of classes in September. The ascertaining of this "plateau effect" would provide a basis for instituting appropriate changes in teaching method that would continue to exert a desirable

impact upon the way students perceive their role in the learning activities.

These questions are indeterminacies arising out of the first year's experiment. In addition, they represent the specific concerns of many teaching innovations of recent origin in the use of technological media, (6) (7) (11) (17) (19) staff utilization, (3) (9) and flexible grouping, variable time scheduling, and teaching procedures designed to encourage the independent, self-sustaining pursuit of learning by the individual student (21). Only as practitioners have available to them reliable answers to such questions will these attempts at educational improvement achieve measurable success.

APPENDIX A

PRE-TEST

(achievement)

PRECEDING PAGE BLANK-NOT FILMED

PHYSICS PRE-TEST

September 1961

1. A space-ship is blasting along in empty space, very far from any stars. If it cuts off its engines, it will

   a. slow gradually to a stop.
   b. go into a circle.
   c. continue at the same speed.

2. When light goes from air into glass

   a. it slows down.
   b. it speeds up.
   c. its speed doesn't change.

3. During a high altitude flight of the X-15, which of the following would remain constant?

   a. weight
   b. temperature
   c. mass
   d. speed
   e. none of these

4. When a car goes around a curve, an outside force acts on the car

   a. forward.
   b. down.
   c. outward.
   d. inward.

6. Steel is stronger than aluminum because

   a. it has heavier atoms.
   b. its atoms are stronger.
   c. its atoms are held together more tightly.

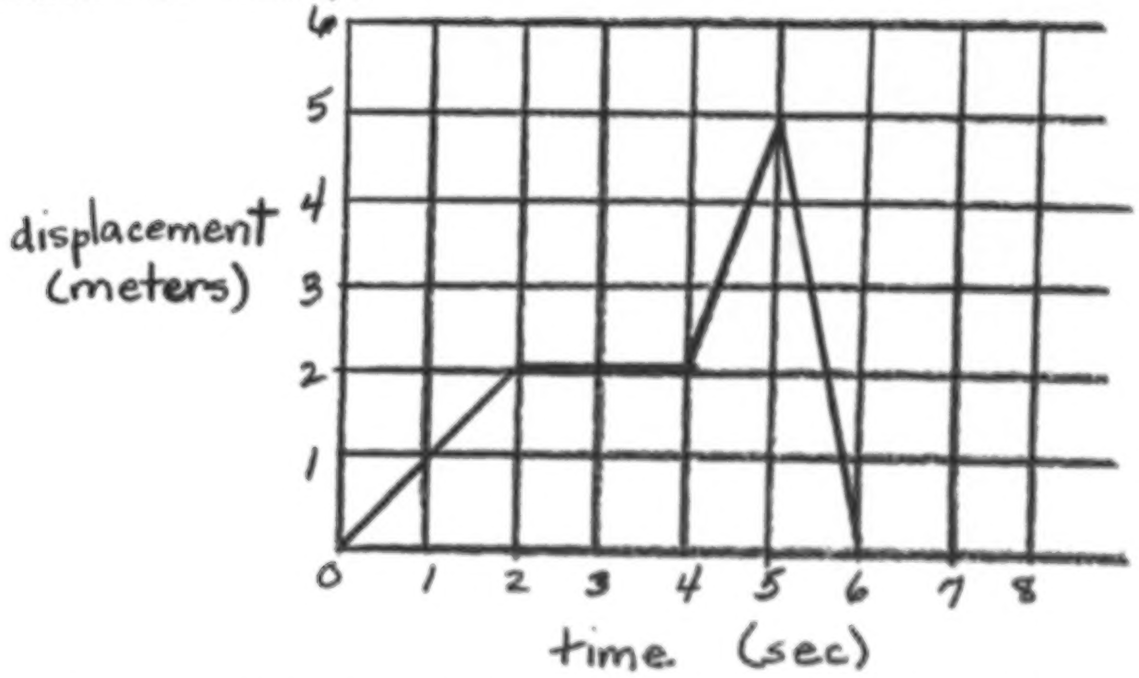
7. A graph of Snell's Law will be a straight line if the plot is

   a. angle i vs angle r.
   b. sin i vs sin r.
   c. angle i vs i/r.
   d. angle i vs sin i/sin r.
   e. none of these.

8. We believe that an electric current in a wire is actually a flow of

   a. negative charges
   b. positive charges
   c. electricity

GRAPH FOR ITEM 9:



9. What was the average velocity of the object during the first four seconds?

   a. ½ meter/sec
   b. 1 meter/sec
   c. 1½ meters/sec
   d. 2 meters/sec
   e. none of these

10. A prism

    a. makes colored light from white light.
    b. separates out the colors in white light.
    c. gives the optical illusion of color.

11. If a pail of water and a glass of water both have the same temperature,

    a. the pail of water contains more heat energy.
    b. the glass of water contains more heat energy.
    c. they contain equal amounts of heat energy.

12. An image can be produced on a screen by using

    a. lenses
    b. mirrors
    c. either mirrors or lenses

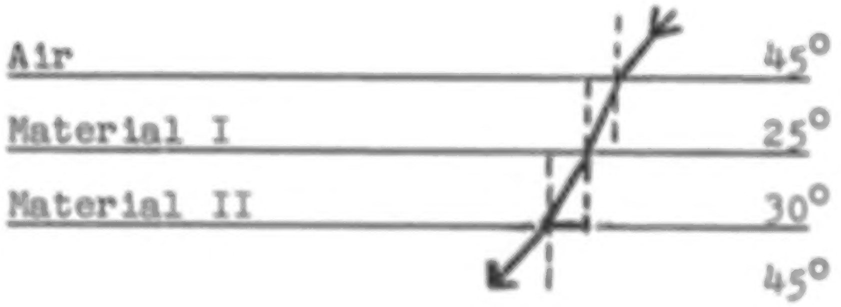
13. Atoms

    a. are indivisible.
    b. can be broken into smaller pieces.
    c. cannot be investigated because they are too small.

14. A Russian astronaut in orbit around the earth sticks his head out the window of his space ship and lets go of an empty vodka bottle; the bottle will

    a. fall away from the ship towards earth.
    b. fly further away from the earth.
    c. stay along side the ship.

A pencil of light passes through two different transparent materials (I and II in the figure), as shown. The faces of the materials are plane and parallel.



15. The frequency of the light in Material I is

    a. less than in air and less than in Material II.
    b. greater than in air and less than in Material II.
    c. greater than in air and greater than in Material II.
    d. less than in air and greater than in Material II.
    e. the same as in air and in Material II.

16. A rock and a piece of Kleenex are dropped from the same place in a large bottle from which the air has been pumped.

    a. The rock will hit first.
    b. The Kleenex will hit first.
    c. They will hit at the same time.

17. By using simple machines like levers and pulleys, we can greatly increase

    a. the amount of work we do.
    b. the amount of force we can exert.
    c. the amount of energy we put out.

To calculate how α-particles scatter as they pass through a gold foil, we can assume with Rutherford, that the α-particle and gold nuclei act as charged points. The following question deals with the differences between the scattering from actual atoms, which include the electronic cloud around the nucleus.

Question 18 continues on the next page.

18. It is found that the number of α-particles scattered through small angles is somewhat different from the number predicted by the Rutherford theory. The reason is that

    a. the nucleus is not a point but has a finite but small size.
    b. the nucleus has electrons about it.
    c. Coulomb's Law does not hold near the nucleus.
    d. the -particle loses less energy to the gold atom than to the point nucleus of the model.
    e. the net electric charge of each atom is zero.

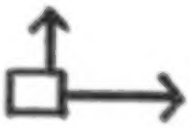
19. The earth is kept spinning by

    a. the forces exerted on it by the moon.
    b. the forces exerted on it by the sun.
    c. both a and b.
    d. its natural inertia .

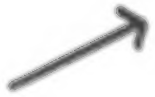
20. The metric system is superior to the English system of measurement in science because

    a. it is more accurate.
    b. it is more convenient.
    c. it is more complicated.

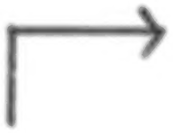
21. The dark arrows represent two forces that are acting on a block. Which of the light arrows best represents the way in which the block would move?



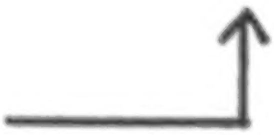
a.



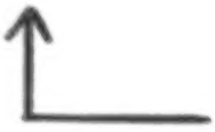
b.



c.

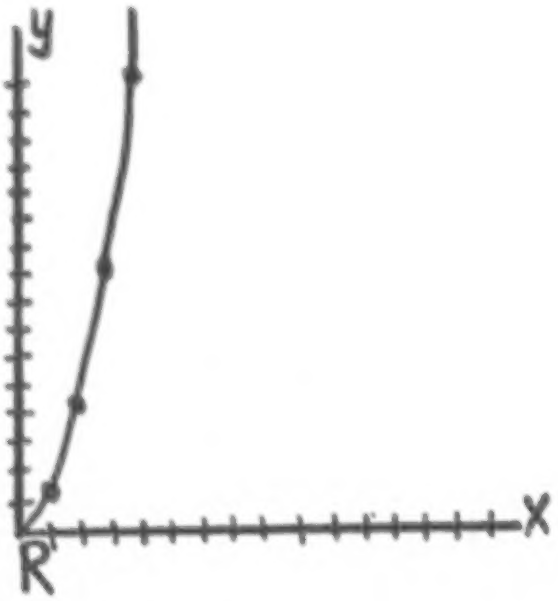


d.

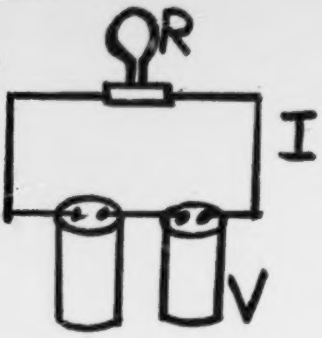


22. The graph at the right shows how two variables x and y are related to each other. In general, we can see that if we make x twice as big, y will become

    a. $\frac{1}{4}$
    b. $\frac{1}{2}$
    c. 2
    d. 4   times as big



23. If the resistance of a light bulb is R, and we connect it to a battery of voltage V, the amount of electric current flowing in the bulb will be



a. VR
b. V/R
c. R/V
d. V - R

24. $10^2 \times 10^3 =$

a. 100^6
b. 100^5
c. 10^5
d. 10^6

25. If ab = cd + e then

a. $d = \dfrac{ab - e}{c}$

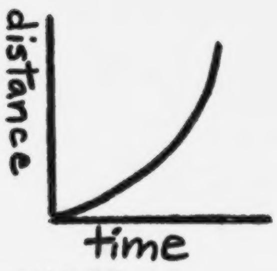
b. $d = \dfrac{ab}{c} - e$

c. d = abc - e

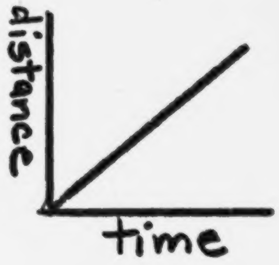
d. d = ab - c - e

26. If a car is moving at constant speed, the graph of how far it goes would look like which of the following:

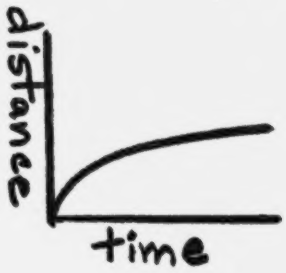
a



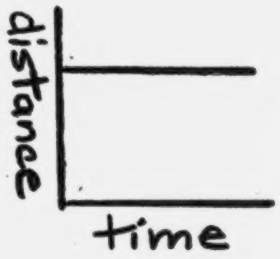
b



c



d



TRUE-FALSE:

27. Relativity teaches that while two observers may not agree about the space intervals or time intervals between two events, they must agree on the combined space-time interval.

28. Every centripetal force on a body is balanced off by an equal "centrifugal" force on the body.

29. The longer the wavelength of a wave, the higher its frequency.

FILL IN THE BLANKS ON THE ANSWER SHEET

30. A ball is thrown upward from a convertible (top down) which is traveling with a uniform velocity down a straight level road at 60 m.p.h. The ball is thrown hard enough to rise to a height of 48 feet. Where will it land? (Neglect any effect of air resistance). You can give its position relative to the car, for instance, 3 feet to the left of the car and 6 feet behind.

31. Two conducting plates of large areas are separated by a distance of 3.1 mm and are connected to the terminals of a 90 volt battery. A small charged sphere halfway between them has a force of 3×10^{-5} nt acting on it.

    a. What force acts on the sphere if the separation is increased to 9.3 mm?

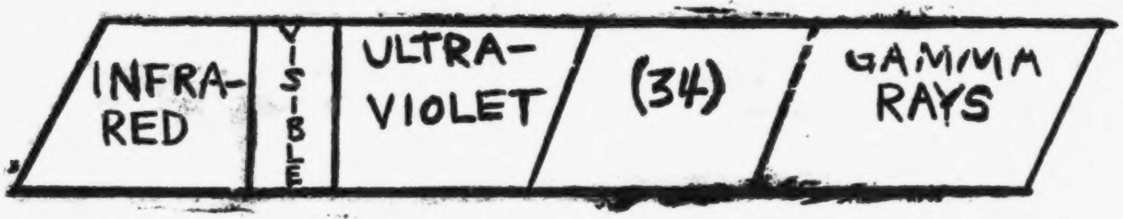
    b. If a 270 volt battery is used in place of the 90 volt battery at the new separation what is the force acting on the sphere?

There are a number of "forces" that affect the behavior of matter in our universe:

32. The most commonly observed force exists between any two _________.

33. The most recently discovered force is difficult to demonstrate and it is more complicated than any of the others. It is a ________________force.

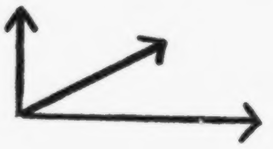
34. As the wavelength of electromagnetic radiation changes, so does the way in which the wave interacts with matter, so that different names are applied to ranges of wavelengths that have certain properties. What is the name of the omitted range (Number 34)?



35. A molecule of oxygen has a mass of 32 amu.

    a. What is the mass of one mole of oxygen? (MKS units)
    b. What is the mass of one molecule of oxygen? (MKS units)
    c. What is the mass of one atom of oxygen? (MKS units)

36. Draw the resultant. (On the answer sheet)



PRE-TEST

Subscore Categories

Lower Mental Processes (knowledge and understanding)

Items 1, 2, 3, 4, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 32, 33, 34

Total 29 items

Higher Mental Processes (problem solving)

Items 9, 25, 30, 31a, 31b, 35a, 35b, 35c, 36

Total 9 items

Total number of items 38

Total possible score 38

APPENDIX B

POST-TEST

(achievement)

PRECEDING PAGE BLANK-NOT FILMED

PHYSICS TEST - FINAL

1. A space-ship is blasting along in empty space, very far from any stars. If it cuts off its engines, it will
    1. slow gradually to a stop.
    2. go into a circle.
    3. continue at the same speed.
    4. none of the above.

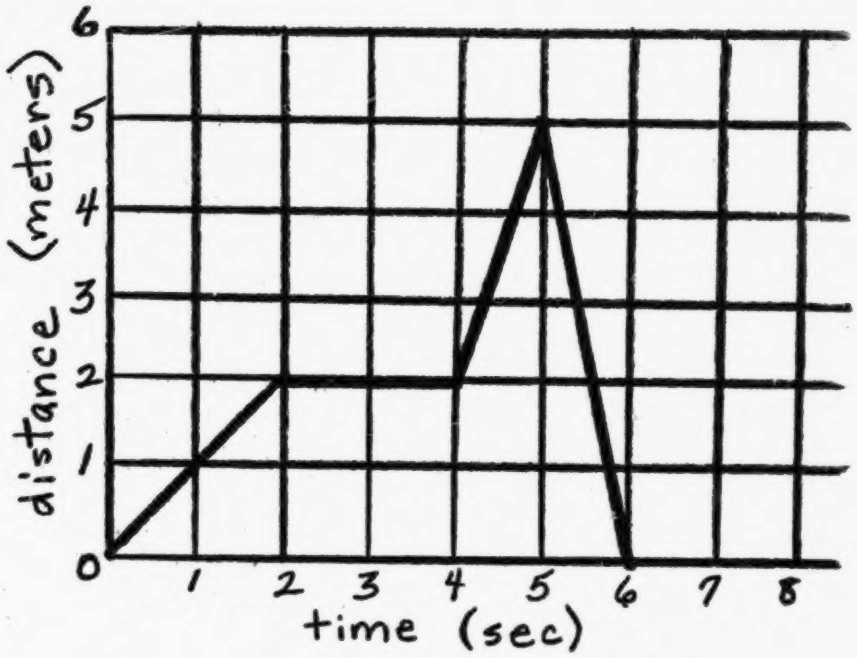
2. When light goes from air into glass it always
    1. slows down.
    2. speeds up.
    3. keeps the same speed.
    4. changes direction.
    5. changes frequency.

3. When a car goes around a curve, an outside force acts on the car
    1. forward.
    2. down.
    3. outward.
    4. inward.
    5. none of the above.

4. A graph of Snell's Law will be a straight line if the plot is
    1. angle i vs angle r
    2. sin i vs sin r
    3. angle i vs i/r
    4. angle i vs sin i/sin r
    5. none of these

Question 5 relates to the following graph:

5. What was the average velocity of the object during the first four seconds?
    1. $\frac{1}{2}$ meter/sec
    2. 1 meter/sec
    3. $1\frac{1}{2}$ meters/sec
    4. 2 meters/sec
    5. none of the above



6. If a pail of water and a glass of water both have the same temperature,

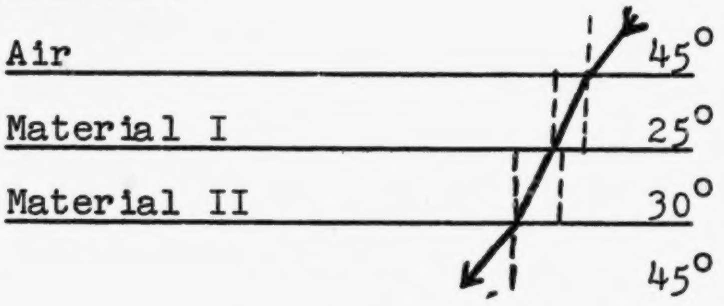
    1. the pail of water contains more heat energy.
    2. the glass of water contains more heat energy.
    3. they contain equal amounts of heat energy.
    4. none of the above.

7. A Russian astronaut in orbit around the earth sticks his hand out the window of his space ship and lets go of an empty vodka bottle. The bottle will

    1. fall away from the ship towards earth.
    2. drift further away from the earth.
    3. stay along side the ship.
    4. stop right where he releases it.
    5. move out ahead of the ship.

Question 8 relates to the following information and diagram:

A pencil of light passes through two different transparent materials (I and II in the figure), as shown. The faces of the materials are plane and parallel.

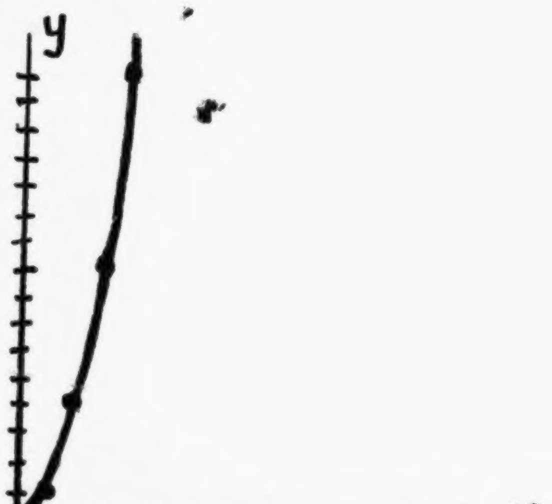


8. The frequency of the light in Material I is

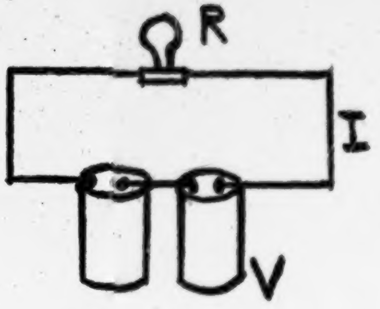
    1. less than in air and less than in Material II.
    2. greater than in air and less than in Material II.
    3. greater than in air and greater than in Material II.
    4. less than in air and greater than in Material II.
    5. the same as in air and in Material II.

9. The graph at the right shows how two variables, x and y, are related to each other. In general, we can see that if we make x twice as big, y will become

    1. $\frac{1}{4}$ times as big.
    2. $\frac{1}{2}$ times as big.
    3. 2 times as big.
    4. 4 times as big.
    5. none of the above.



Question 10 relates to the diagram at the right.



10. If the resistance of a light bulb is R, and we connect it to a battery of voltage V, the amount of electric current flowing in the bulb will be

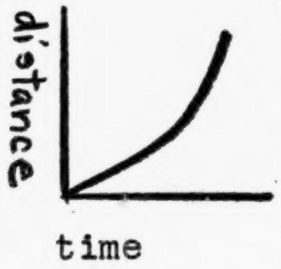
    1. VR
    2. V/R
    3. R/V
    4. V-R
    5. none of the above.

11. $10^2 \times 10^3$ =

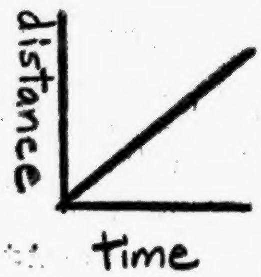
    1. 100^6
    2. 100^5
    3. 10^5
    4. 10^6
    5. none of the above

Question 12 relates to the following graphs:

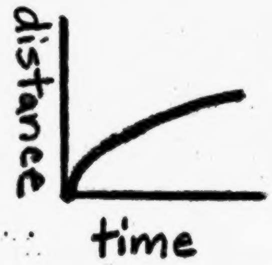
a



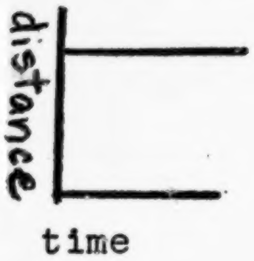
b



c



d



12. If a car is moving at constant speed, the graph of how far it goes would look like which of the above?

    1. a
    2. b
    3. c
    4. d
    5. none of these

13. The relationship between wave length λ and frequency f of a wave that travels with velocity v is:

    1. $f = v\lambda$
    2. $f = \frac{v}{\lambda}$
    3. $f = \frac{\lambda}{v}$
    4. $f = \lambda + v$
    5. $f = v - \lambda$

14. A ball is thrown upward from a convertible (top down) which is traveling with a uniform velocity down a straight level road at 60 m.p.h. The ball is thrown hard enough to rise to a height of 48 feet. Where will it land? (Neglect any effect of air resistance).

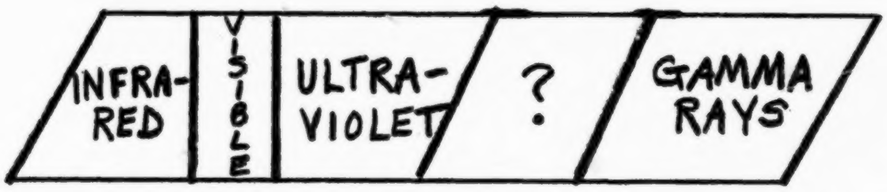
    1. ahead of the car
    2. behind the car
    3. in the car
    4. to the left of the car
    5. to the right of the car

Question 15 relates to the following information and diagram:

As the wave-length of electromagnetic radiation changes, so does the way in which the wave interacts with matter, so that different names are applied to ranges of wave-lengths that have certain properties.

15. What is the name of the omitted range?

    1. radio
    2. X-rays
    3. radar
    4. cosmic rays
    5. cathode rays



16. Of the following numbers, which has the largest number of significant figures:

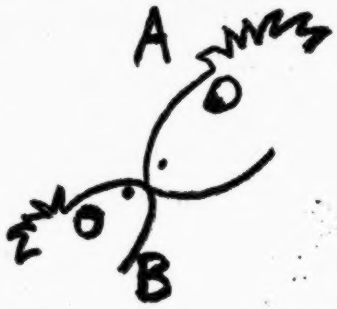
    1. 20400
    2. 2040.0
    3. 0.2040
    4. 0.002040

17. If a grain of salt is of the order of 1 mm on an edge, how many atoms does a grain of salt contain? The diameter of an atom is of the order of 10^{-10}m.

    1. 10^{10}
    2. 10^{15}
    3. 10^{20}
    4. 10^{25}
    5. 10^{30}

Questions 18 and 19 refer to the following diagram and information:

Animal A weighs 8 times as much as animal B of similar shape.



18. How many times taller is A than B?

    1. 2 times taller
    2. 3 times taller
    3. 4 times taller
    4. 8 times taller
    5. 16 times taller

19. How many times faster does A lose heat than B?

    1. 2 times faster
    2. 3 times faster
    3. 4 times faster
    4. 8 times faster
    5. 16 times faster

20. The height of a tall man is about ________ meters? (Nearest integer)

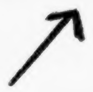
    1. 1/10 meters
    2. 1/2 meters
    3. 1 meter
    4. 2 meters
    5. 10 meters

21. On a distance vs. time graph, the tangent to the curve at a given point represents

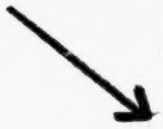
    1. position
    2. displacement
    3. average velocity
    4. instantaneous velocity
    5. acceleration

Question 22 refers to the following diagrams:

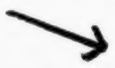
A



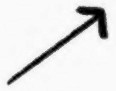
B



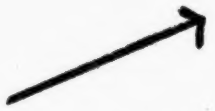
22. A + B =



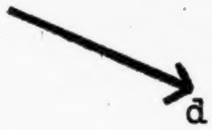
a



b



c



d

    1. a
    2. b
    3. c
    4. d
    5. none of these

23. If a source of light is placed 3 meters from a concave mirror with a focal length of 1 meter, the image will be

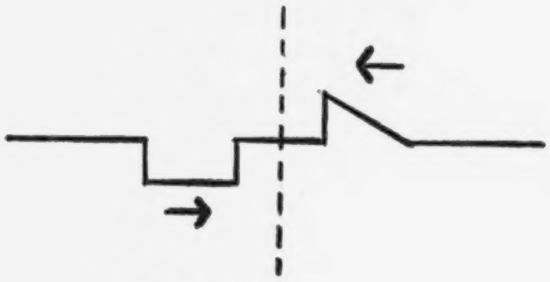
    1. located between 1 and 2 meters and be inverted.
    2. located between 1 and 2 meters and be erect.
    3. located between 2 and 3 meters and be inverted.
    4. located between 2 and 3 meters and be erect.
    5. none of the above.

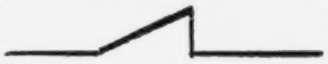
24. A wave passes through a hole. Diffraction effects will be most noticeable with

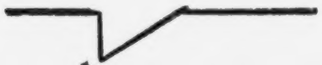
    1. a long wave and a small hole.
    2. a long wave and a large hole
    3. a short wave and a small hole.
    4. a short wave and a large hole.
    5. all the same.

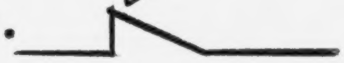
Question 25 relates to the following diagram and information:

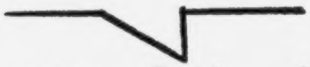
25. Two wave shapes are traveling toward each other. The best composite or superposed wave-form would be:



1. 

2. 

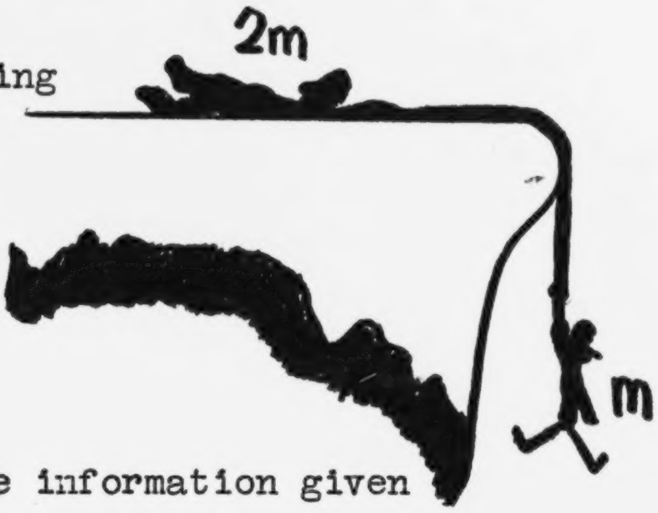
3. 

4. 

5. none of the above

Question 26 relates to the following diagram:

26. The acceleration of the man hanging over the frictionless cliff is (assume the rope is weightless)



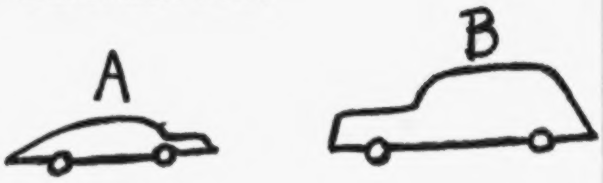
1. g
2. 1/2 g
3. 1/3 g
4. 2/3 g
5. impossible to tell from the information given

27. A car is going around a curve at too great a speed and skids on to the shoulder of the road. The most acceptable explanation for this would be

1. too much centripetal force.
2. too much centrifugal force.
3. not enough centripetal force.
4. not enough centrifugal force.
5. none of the above.

Question 28 relates to the following diagram and information:

Two cars hit head on; car "A" is 1/2 the mass of car "B".



28. It would be safer to be in car "A" than in car "B" under which one of the following conditions?

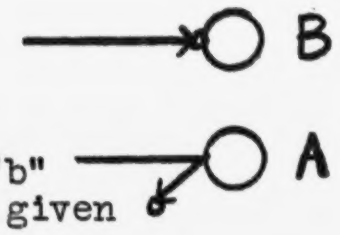
    1. if car "A" is going less than 1/2 as fast as car "B"
    2. if car "A" is going the same speed as car "B"
    3. if car "A" is going more than 2 times faster than car "B"
    4. if car "A" is going more than 4 times faster than car "B"
    5. none of the above

Question 29 relates to the following information and diagrams:

Nucleus "a" and nucleus "b" are each struck by neutrons of the same speed. A neutron bounces off nucleus "a" and a neutron is captured by nucleus "b".

29. The impulse is

    1. greater for "a"
    2. greater for "b"
    3. the same for both
    4. greater for the most massive of "a" or "b"
    5. impossible to tell from the information given



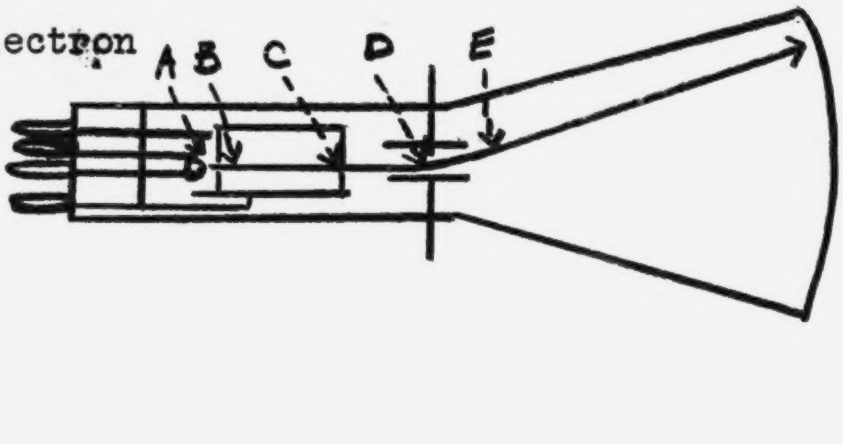
30. Which of the following is not conserved in a closed system?

    1. momentum
    2. angular momentum
    3. total energy
    4. kinetic energy
    5. charge balance

Question 31 refers to the following diagram:

31. The energy of the electron will be greatest at

    1. A
    2. B
    3. C
    4. D
    5. E



32. A charged particle is moving in a circular path in a magnetic field. The circle would become larger if

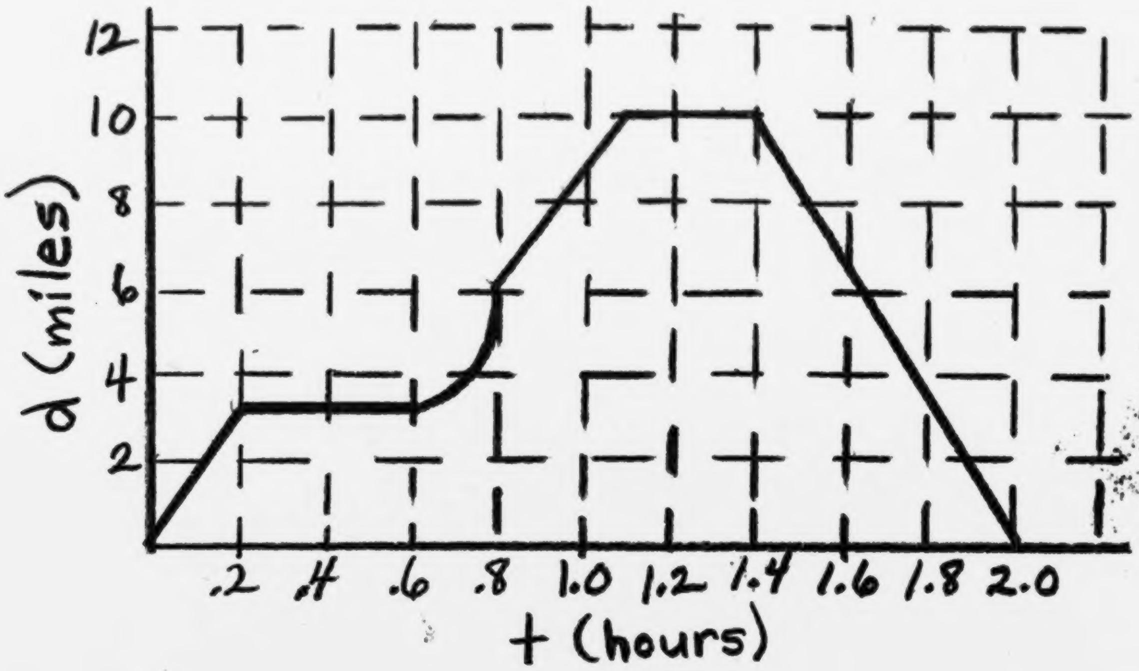
    1. the particle were moving slower.
    2. the particle had less mass.
    3. the particle had a greater charge.
    4. the magnetic field was weaker.
    5. none of the above.

33. Breaking a nucleus into lighter nuclei results in a release of energy

    1. always.
    2. only with a heavy nucleus.
    3. only with a light nucleus.
    4. never.
    5. none of the above.

Questions 34, 35, 36, and 37 relate to the following information and graph:

This is a distance-time graph of an automobile moving along a straight road.



34. In the first .2 hours, the car went

    1. 0.3 miles
    2. 3 miles
    3. 2.1 miles
    4. 1.5 miles
    5. none of the above

35. The auto was traveling at its greatest speed at (see graph on previous page)

    1. .1 hr.
    2. .4 hr.
    3. .8 hr.
    4. 1.6 hr.
    5. none of the above.

36. The car accelerated in the time interval (see graph on previous page)

    1. 0 -- .2 hr.
    2. .2 -- .6 hr.
    3. .6 -- .8 hr.
    4. 1.4 -- 2.0 hr.
    5. none of the above.

37. The area under the distance-time curve gives

    1. speed
    2. distance
    3. time
    4. slope
    5. none of the above

38. Which of the following statements does not characterize a gas?

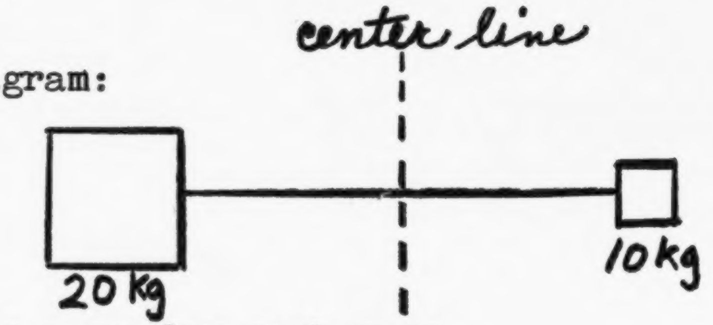
    1. Gases have low density.
    2. The molecules are in random motion.
    3. Gases are made up of closely spaced molecules.
    4. The average speed of the molecules of a gas depends on the temperature.
    5. none of the above.

39. Science experiments often involve variables. Which of the following statements most clearly expresses the meaning of independent variable?

    1. The independent variable is independent. The dependent variable is dependent.
    2. The independent variable is plotted on the X-axis of the rectangular coordinate system.
    3. The independent variable is a record of something seen, heard, smelled, tasted, or felt.
    4. The independent variable is that factor controlled and changed by the experimenter.
    5. none of the above.

(Item 40 was omitted from the test).

Question 41 relates to the following diagram:



41. If two masses of 20 kg and 10 kg, respectively, connected by a rubber band, are stretched apart and released, it follows that

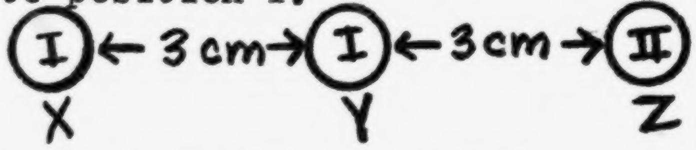
    1. the stretching force is not the same for each mass.
    2. the larger mass will have the greater acceleration.
    3. the masses will meet at a point midway between them.
    4. the larger mass will travel the greater distance before striking.
    5. the smaller mass will have the greater rate of change in velocity.

42. The assertion that like charges repel one another is best regarded as

    1. an arbitrary definition.
    2. an expression of the observed fact that charged bodies which repel one another act alike toward all other electrified bodies.
    3. based upon the observation that charged bodies of the same material repel one another.
    4. the only possibility remaining once it has been ascertained that unlike charges attract one another.
    5. a consequence of Franklin's Law.

Question 43 refers to the following information and diagram:

Bodies I and II, when in position X and Z, are given equal like charges. Body I is now moved to position Y.



43. The force between the bodies will now be

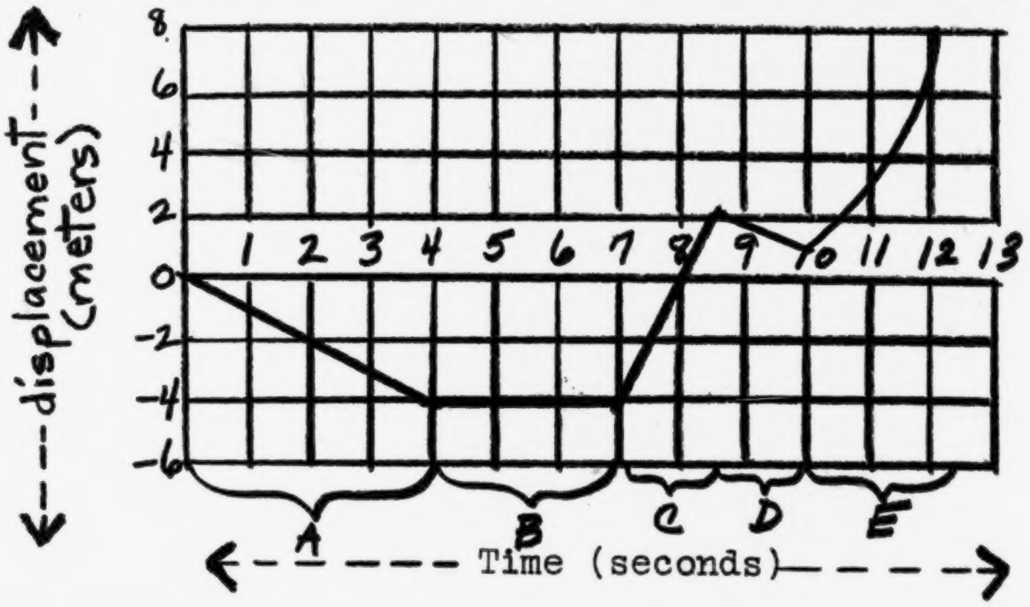
    1. unchanged.
    2. one-fourth as great.
    3. one-half as great.
    4. twice as great.
    5. four times as great.

44. The significance of the Millikan experiment is that it gives evidence for the

    1. retarding force of air on a moving sphere.
    2. preciseness of Coulomb's Law.
    3. graininess of electricity.
    4. existence of the electrical force field.
    5. none of the above.

Questions 45 and 46 relate to the following information and graph:

An object is moving along a straight line. The graph shows its displacement from the starting point as a function of time. Various sections of the graph are identified by the letters A,B,C,D, and E.



45. Which section of the graph represents a time during which the object was at rest?

    1. A
    2. B
    3. C
    4. D
    5. E

46. What was the instantaneous velocity of the object at the end of the fifth second?

    1. 4 meters/sec
    2. 2 meters/sec
    3. 4/6 meters/sec
    4. 0 meters/sec
    5. -4/6 meters/sec

Questions 47 and 48 relate to the following information:

Several solid objects, whose volumes and densities are given below, are to be compared with each other by the use of an equal arm balance. A number of identical copies of each of the objects is available.

	Volume	Density
Object A	1 cm^3	1 gm/cm^3
Object B	2 cm^3	1 gm/cm^3
Object C	2 cm^3	2 gm/cm^3
Object D	1 cm^3	2 gm/cm^3
Object E	3 cm^3	1 gm/cm^3

47. Object B can be balanced by

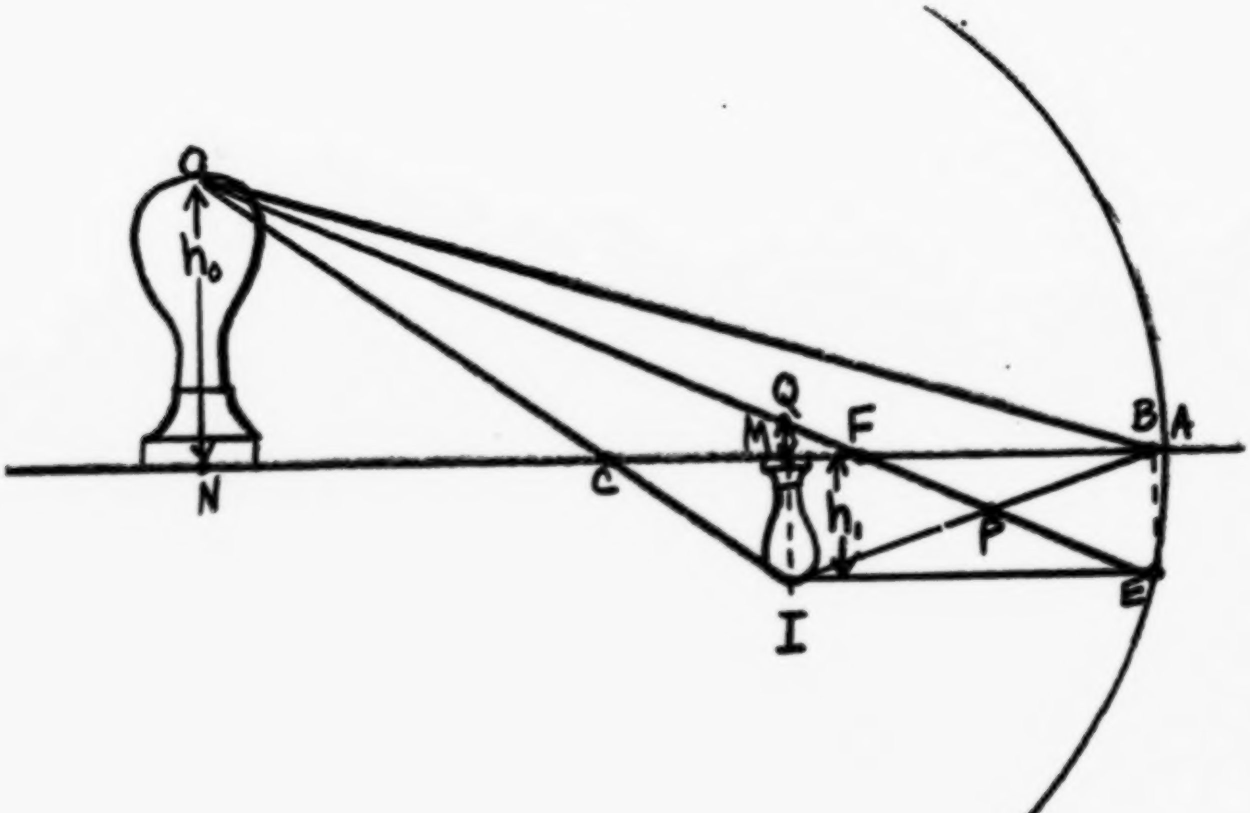
1. object A.
2. either object C or object E.
3. object C.
4. object D.
5. either object C or object D.

48. Object D plus object E can be balanced by

1. object B plus object C
2. object A plus object B.
3. two objects identical to A plus object B.
4. object A plus two objects identical to object B.
5. two objects identical to B plus object D.

Questions 49 and 50 relate to the following information and diagram:

A light bulb and its image are shown together with a concave mirror. A number of pairs of similar triangles occur in the diagram.



49. From which of the following relations of similarity can one conclude that the ratio of object height to image height is the same as the ratio of object distance from A to image distance from A?

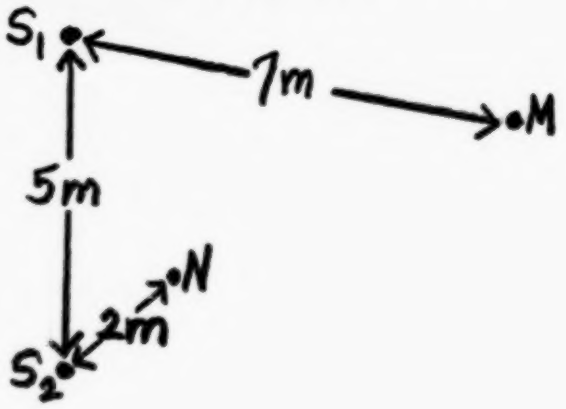
    1. The similarity of triangles CNO and CMI
    2. The similarity of triangles FNO and FBE
    3. The similarity of triangles ANO and AMI
    4. The close similarity of triangles PQI and PAE
    5. None of the above.

50. From which of the following relations of similarity can one conclude that the ratio of object height to image height is approximately determined by the focal length of the mirror alone?

    1. The similarity of triangles CNO and CMI
    2. The similarity of triangles FNO and FBE
    3. The similarity of triangles ANO and AMI
    4. The close similarity of triangles PQI and PAE
    5. None of the above.

Questions 51 and 52 relate to the following information and diagram:

Two very small identical loudspeakers, each of which is radiating sound uniformly in all directions, are placed at points S_1 and S_2 as shown in the diagram. They are connected to a source so that they radiate in phase with each other, the wave length of the sound emitted being 2.00 meter. The speed of sound may be taken as 300 meters/second.



51. Point M, a nodal point, is 7 meters from S_1 and at least 7 meters from S_2. The smallest distance that M can be from S_2 is

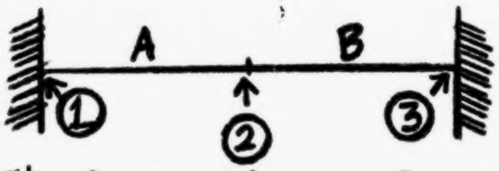
    1. 7 meter
    2. 8 meter
    3. 9 meter
    4. 10 meter
    5. 12 meter

52. Suppose that loudspeaker S_2 is adjusted so that it radiates out of phase with S_1, the phase delay of S_2 with respect to S_1 being 1/2. Point N, which is 2 meters from S_2, will be a nodal point if its distance from S_1 is

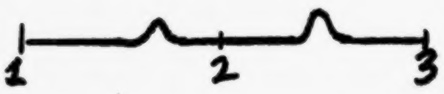
   1. 2 meter
   2. 3 meter
   3. 4 meter
   4. 5 meter
   5. 7 meter

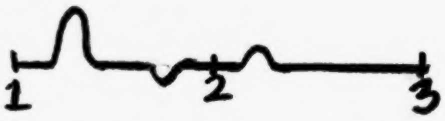
Questions 53 and 54 relate to the following information and diagrams:

A and B represent two cords of equal length tied together at point 2 and tied down at points 1 and 3.



The diagrams numbered 53 and 54 show various pulses traveling along the cords. In each case, the pulses were produced by a single blow, and no reflection has taken place at either end.

53


54


In answering questions 53 and 54, select the condition which could account for the pulses appearing in the diagram bearing the same number as the question.

53. Under which of the following conditions could the pulses in diagram 53 have appeared?

   1. A and B are equally heavy, and the blow was struck at 2.
   2. A is heavier than B, and the blow was struck at 1.
   3. A is heavier than B, and the blow was struck at 3.
   4. A is lighter than B, and the blow was struck at 1.
   5. A is lighter than B, and the blow was struck between 1 and 2.

54. Under which of the following conditions could the pulses in diagram 54 have appeared?

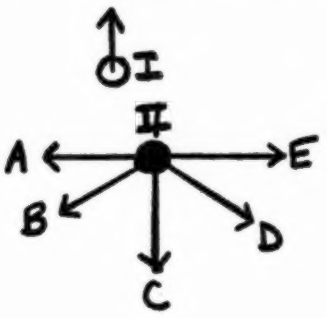
   1. A is heavier than B, and the blow was struck at 1.
   2. A is heavier than B, and the blow was struck between 1 and 2.
   3. A is lighter than B, and the blow was struck at 1.
   4. A is lighter than B, and the blow was struck between 1 and 2.
   5. A is lighter than B, and the blow was struck at 2.

Questions 55 and 56 relate to the following information and diagrams:

A ball (I) having a mass of 1.0 kg and moving at a speed of 4.0 meter/second strikes a glancing blow on a second ball (II). After the collision, ball I is moving at right angles to its original direction of motion, as shown in the diagram, with a speed of 3.0 meter/second.

Before collision

After collision



55. The direction of motion of ball II after the collision might be represented by the arrow labeled

    1. A
    2. B
    3. C
    4. D
    5. E

56. It is found that the speed of ball II after the collision is 1.25 meter/second. The mass of ball II is

    1. greater than 2.0 kg
    2. between 1.0 kg and 2.0 kg
    3. equal to 1.0 kg
    4. between 0.5 kg and 1.0 kg
    5. less than 0.5 kg

Questions 57 and 58 relate to the following information:

To calculate how α-particles scatter as they pass through a gold foil, we can assume, with Rutherford, that the α-particle and gold nuclei act as charged points. The following two questions deal with the differences between the scattering of α-particles from idealized point nuclei and the scattering from actual atoms, which include the electronic cloud around the nucleus.

57. If an α-particle of 10^7 ev passes through the electron clouds of 10^5 atoms before it comes to rest, the average energy loss per atom passed is

    1. 1 ev
    2. 10 ev
    3. 10^2 ev
    4. 10^3 ev
    5. 5×10^4 ev

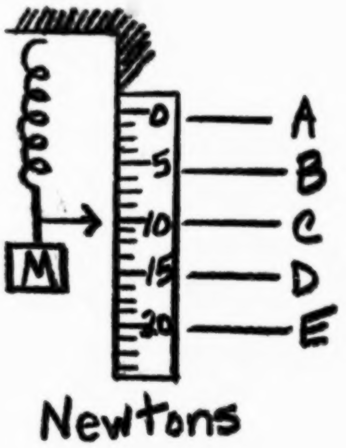
58. The smallest distance that the α-particle described in question 57 would travel (as measured along its path through the gold) before coming to rest would be approximately

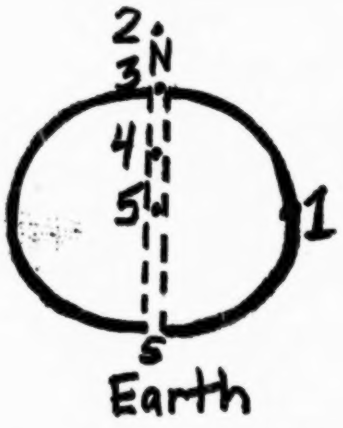
1. 10 meters
2. 10^{-1} meters
3. 10^{-3} meters
4. 10^{-5} meters
5. 10^{-7} meters

Questions 59 and 60 relate to the following information and diagrams:

Assume that it is possible to drill a small tunnel completely through the earth from the North Pole to the South Pole as shown in the diagram.

A standard mass M is to be weighed at various positions relative to the earth's surface, using a spring balance to measure the gravitational force on the mass, as shown in the diagram. With no mass attached to the spring, the pointer is at A. With the mass M, the spring deflects to scale reading C when a measurement is taken at Point 1. Assume that the mass of the spring is negligible in comparison with that of mass M. For each of the following conditions, select the reading on the scale to which the pointer would be closest.





59. The mass M is weighed at Point 2, while moving freely in a circular orbit 2000 miles above the earth's surface. Consider the earth to be a homogeneous sphere.

1. A
2. B
3. C
4. D
5. E

60. The mass M is weighed at Point 4, midway between the surface of the earth and the center of the earth.

1. A
2. B
3. C
4. D
5. E

POST-TEST

Subscore Categories

Lower Mental Processes (knowledge and understanding)

Items 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 41, 42, 43, 44
Total 41 items

Higher Mental Processes (problem solving)

Items 5, 14, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60
Total 18 items

Total number of items 59

Total possible score 59

APPENDIX C

Q-SORT

PRECEDING PAGE BLANK-NOT FILMED

Q-Sorts

The Q-sort instrument administered to each student in September, January, and June contained the following materials: 28 tasks, each listed on a separate 3x5 index card, numbered from 10 through 37 and arranged in random order; 4 category sheets; 1 tally sheet; and 1 instruction sheet.

The tasks, and the subscore categories to which they belong (in parentheses), are as follows:

10 determine how the student is progressing, how well he is doing apart from examinations (evaluation)

11 decide on how the student's final grade is to be determined (evaluation)

12 decide on how the student can deal with those areas in which he is weak (evaluation)

13 decide what student(s) would investigate special problems arising out of class activities (evaluation)

14 determine ways in which the student can make better progress in the course (evaluation)

15 see that the student takes good notes in the course of class lectures, readings, and film materials (evaluation)

16 identify ways in which the course could be improved and made more interesting (evaluation)

17 decide whether the student needs special help (evaluation)

18 decide what the student can expect to learn in the class (learning experiences)

19 see that the student understands the ideas and principles in the course (inquiry)

20 see that the student knows how to use principles in physics to explain new situations and solve new problems (inquiry)

21 see that the student is familiar with current problems, ideas, and theories in physics (inquiry)

22 think up experiments that would test laws of physics discussed in class (inquiry)

23 interpret the results of experiments done in class (inquiry)

24 draw conclusions from experiments conducted in the course (inquiry)

25 identify and define the question which an experiment is supposed to answer (inquiry)

26 determine when the student has enough data and of the right kind to answer the question in a problem (inquiry)

27 decide the exact procedure or way in which an experiment is to be done (inquiry)

28 raise questions that challenge the conclusions drawn by other students from their experiments (inquiry)

29 locate other reference material such as books, articles in magazines and periodicals, etc., that are related to the course (learning experiences)

30 select the experiments that are done in the course (learning experiences)

31 identify the chapters, pages, etc., in textbooks, magazines, and periodicals that are related to the course (learning experiences)

32 determine what kind and how much homework is done by the student (learning experiences)

33 determine how many experiments are to be done by a given student (learning experiences)

34 decide whether the amount and quality of work done in a task are adequate (evaluation)

35 determine what kind and how much use the student makes of the available resources in physics (learning experiences)

36 make certain that the class pays attention (learning experiences)

37 decide whether and how a student is disciplined (learning experiences)

Subscore categories:

Evaluation 10,11,12,13,14,15,16,17,34 (9)

Inquiry 19,20,21,22,23,24,25,26,27,28 (10)

Learning Experiences 18,29,30,31,32,33,35,36,37 (9)

The instruction sheets, which were distributed one at a time, were the following: "Whose job do you think it is to..."; "Whose job do you think the teacher would say it is to..."; "Who actually did perform this task most often throughout the year?" (The last Q-sort was administered in June only.)

WHOSE JOB DO YOU THINK IT IS TO...

WHOSE JOB DO YOU THINK THE
TEACHER WOULD SAY IT IS TO...

WHO ACTUALLY DID PERFORM THIS
TASK MOST OFTEN THROUGHOUT
THE YEAR?

Four half-sheets of paper indicated the category titles: STUDENT, STUDENT and TEACHER (or TEACHER and STUDENT), TEACHER, and NEITHER.

STUDENT

STUDENT
and
TEACHER

TEACHER

NEITHER

YOU

_____10

_____11

_____12

_____13

_____14

_____15

_____16

_____17

_____18

_____19

_____20

_____21

_____22

_____23

_____24

_____25

_____26

_____27

_____28

_____29

_____30

_____31

_____32

_____33

_____34

_____35

_____36

_____37

Name____________________

School____________________

Teacher____________________

Period____________________

1

(The tally sheets were coded for each administration so that they would be easily identifiable.)

PRECEDING PAGE BLANK-NOT FILMED

During the first administration of the Q-sorts in September, January, and June, the student was asked to sort the tasks according to "Whose job he (the student) thought it was to ..." After sorting the cards into the four piles, the student was asked to write the appropriate identification information on the top of the tally sheet, and to tally the tasks on the tally sheet marked YOU by writing the appropriate letter of the category, i.e., S for STUDENT, ST or TS for STUDENT and TEACHER or TEACHER and STUDENT, T for TEACHER, and N for NEITHER, next to the number of the task on the tally sheet. After all 28 tasks were tallied, the student was asked to hand in the instruction sheet and the tally sheet and to shuffle the 28 cards. He was then given another instruction sheet which asked "Whose job do you think the teacher would say it is to ..." and a new tally sheet. He was then instructed to sort the cards according to this new instruction sheet, write the name of the teacher across the top, and to once again tally the cards. He then handed in the second instruction sheet and tally sheet, reshuffled the cards, and, in September and January, turned in the packet of cards and category sheets, which were then ready to be used in the next administration of the Q-sorts.

During the administration of the Q-sorts in September, separate packets were prepared for each student for each Q-sort, that is, one packet for "Whose job do you think it is to ..." and one for "Whose job do you think the teacher would say it is to ..." Moreover, instead of category sheets, four envelopes were enclosed, one each for Student, Teacher, Student and Teacher (or Teacher and

Student), and Neither, and the students were instructed to put the cards in each category into the appropriate envelopes, seal them, and turn in the entire packet after each sort. This entailed a great deal of unnecessary work on the part of the project staff, both before and after each administration, in terms of assembling, transporting, tallying, and reassembling the packets. After it was decided to let the students tally their own cards, it was only necessary to have them identify themselves on the tally sheet, and, as soon as the cards were reshuffled, all that was necessary for the next administration was to distribute new instruction sheets and new tally sheets. The staff, then, was only required to translate the initials into numbers, for it was felt that a more valid sample would be obtained if the students were not aware of the weight given to each category.

In the June administration of the Q-sorts, several modifications were made. In the September Q-sort, since the students were not yet familiar with their physics teachers, they were told to keep in mind "teachers in general." In the January Q-sorts, after a semester in physics, they were told to keep in mind their "physics teachers." In June, the control students were told to keep in mind their "physics teachers," but, since the experimental classes were being taught by two teachers, it was decided to administer the "teacher" sort twice. The students were told to sort the cards as they thought Teacher A would sort them on the first administration, and then as they thought Teacher B would sort them on the second administration of the Teacher sort. It was necessary, then, to identify the teacher on each tally sheet.

In addition, it was decided in June to administer a "Did" sort, that is, the students were instructed to sort the cards according to who actually did perform each task most often during the year. There were, in effect, two decisions to be made: (1) whether someone actually did perform the task often enough to be judged, and (2) if so, who did it most often -- Teacher, Student, or Teacher and Student. If the task was not performed with some regularity, the students were instructed to place the card in the Neither category.

The Q-sorts were scored according to the following point system: S = 4, ST or TS = 3, T = 2, N = 1. If the student omitted up to 3 tasks, the omitted tasks were scored so that they would count against the project. On the assumption that a 4 was the most favorable response, the task was usually given a 2. The total score for each student was computed by adding the scores for all the tasks. The three subscores were computed by adding the scores in each subscore category.

Q-Sort Reliability

Reliability of the Q-Sort instrument was tested in two University of Chicago Laboratory High School physics classes. The two administrations of the Q-Sort were separated by one day.

The correlation between Administration 1 and Administration 2 in Group I was .708.

The correlation between Administration 1 and Administration 2 in Group II was .599.

The correlation between Administration 1 and Administration 2 in the combined groups was .649.

APPENDIX D

STUDENT OPINION SURVEY

PRECEDING PAGE BLANK-NOT FILMED

STUDENT OPINION SURVEY

Name ____________________ School ____________________

Teacher ____________________ Period ____________________

Students differ in feelings about the courses they are taking in school. We would like to know how you feel about the courses that you have.

Begin by listing all the courses you are taking by writing the specific subject name under the general heading that is provided below. The letter symbol that is underlined will be used to represent the subject throughout the remainder of the questionnaire. For instance, if you are taking American Literature you would write the course title "American Literature" under the general heading English, and this course would be represented by the letter E. At this point, fill in the names of all the courses you are now taking in the appropriate spaces below.

E English ____________	SS Social Studies ____________	Ma Mathematics ____________
F Foreign Language ____________	PE Physical Education ____________	Sc Science ____________
B Business Courses ____________	Mu Music ____________	H Home Economics ____________
I Industrial Courses (shops) ____________	A Art ____________	O Other ____________

The next thing to do is for you to write the specific course names and the letter symbols, underlined above, in the spaces provided at the top of the next page. Do this and then return to the remainder of the instructions on this page.

From here on, the task is for you to rate all of your courses on the list of items on the next page. Read each statement carefully. Then place the letter symbol for each course in the space on the scale that best represents your opinion about this course. For instance, a student taking E American Literature, SS World History, PE Physical Education, Ma Algebra, and Sc Biology rated these courses on the following statement in this manner:

> "To what extent do each of your classes consist of students whom you admire?"

```
  . Ma . Sc .     .     . PE .    . E  .     .      . SS .
not at                                              completely
all
```

Notice that this student placed the letters SS at the extreme right of the scale. This indicates that he admires all the students in his World History class. The letters Ma are placed on the extreme left of the scale, indicating that there are no students in Algebra that he admires. In his opinion the other courses fall between these extremes and are rated accordingly. This student spaced his ratings over the entire length of the scale. However, another student might have placed his ratings all on the left end of the scale, while still another student would want to use only the right end. From this you can see that you should feel free to use that part of the scale that best represents your opinion about the statement. Finally, as in the example, you are to use the spaces provided between the points on the scale. Please do not place any ratings above the points themselves.

Remember you are to rate all of your courses on an item before you proceed to the next item.

**** Note: Items 20-29 were included on the second administration (June) only.

Letter Symbol	Course Title	Letter Symbol	Course Title

1. In general, how meaningful and rewarding is each of your courses?

. . . .
not at all — completely

2. To what extent does each course make use of subject materials of the sort you would like to study or work with next year?

. . . .
not at all — completely

3. To what extent does each of your courses deal with things that are interesting to talk about outside of class?

. . . .
hardly ever — most of the time

4. To what extent does each of your courses have a group of students you would like to work with again next year?

. . . .
not at all — completely

5. To what extent are you willing to do the work required in each of your courses?

. . . .
not at all — completely

6. To what extent does each course further your plans for things you want to do after you leave high school?

. . . .
not at all — completely

7. In what ways have each of these courses opened new interests or things for you to do?

. . . .

no ways at all	lots of ways

8. What per cent of the time in each course is spent on activities which personally you enjoy?

. . . .

none of the time	all of the time

9. To what extent does each course have a teacher(s) with whom you would like to work again next year?

. . . .

would not like at all	would like completely

10. To what extent do you look forward to going to each of these courses?

. . . .

not at all	completely

11. To what extent have each of the courses given you as an individual opportunity to practice or try out some special skill or talent which you have?

. . . .

little or no opportunity	lots of opportunity

12. To what extent in each course are help and assistance available (teachers, facilities, materials, etc.) to further your own learning?

. . . .

not at all	completely

13. What part of the time in each course is spent on activities in which you are really concentrating and working hard?

. . . .

none of the time	all of the time

14. To what extent is (are) the course teacher(s) familiar with you and your work?

. . . .

not at all	completely

15. How often in each course have you opportunity to pursue a particular question, idea or personal interest?

. . . .

none of the time	all of the time

16. How fair is the evaluation of your work in each of your courses?

. . . .

not at all	completely

17. How much opportunity in each of your courses do you have to contribute to the progress of a group of students in a common activity?

. . . .

little or no opportunity	lots of opportunity

18. To what extent are you encouraged to work up to your capacity in your courses?

. . . .

hardly ever	most of the time

19. To what extent are you expected to work beyond your capacity in your courses?

. . . .

hardly ever	most of the time

Please complete the next section by placing a check mark (✓) at that point on each scale line that best represents how you feel about the idea. You are encouraged to use the whole scale by locating your check anywhere along it. For instance, your judgment of any of the ideas listed below might be higher than "some" but not as high as "quite a bit." Therefore, your check should be placed in this manner:

	✓	
some		quite a bit

Read the words below the scale each time to make sure you are marking it correctly.

To what extent have the following helped you in getting the most out of your physics course this year? (Respond to those items below that apply to your class).

20. PSSC motion pictures

very little, could do without	some	quite a bit	a lot, couldn't do without

21. Overhead projector

a lot, couldn't do without	quite a bit	some	very little, could do without

22. In-class television

very little, could do without	some	quite a bit	a lot, couldn't do without

23. Reference books and magazines in science office and classroom

a lot, couldn't do without	quite a bit	some	very little, could do without

24. Textbook

very little, could do without	some	quite a bit	a lot, couldn't do without

25. Laboratory guide

a lot, couldn't do without	quite a bit	some	very little, could do without

26. Slide-Tape presentations

very little, could do without	some	quite a bit	a lot, couldn't do without

27. Two teachers teaching the course

a lot, couldn't do without	quite a bit	some	very little, could do without

28. Dividing up the whole class into different groups

very little, could do without	some	quite a bit	a lot, couldn't do without

29. Daily "free access" period (School B - period 7-8, 1:30 - 2:00 p.m.)

a lot, couldn't do without	quite a bit	some	very little, could do without

On this page we are interested in how you react in another way to your physics course. We have made up a list of opposite words against which you are to say what the course means to you.

First: Decide which side (word) in your opinion best fits your physics course.

Second: Decide how much or to what degree you feel this way.

There are no right answers. Your opinion is what matters. Even where you don't have a strong opinion be sure to mark a choice.

Circle . when you feel slightly this way.
Circle .. when you feel quite a bit this way.
Circle ... when you feel strongly this way.

If, for example, you feel slightly that, say, your best friend is unfair, the marking would be as follows:

Fair ... .. . [✓ .] .. ... Unfair

Your Physics Course

Tight	...	..	.	.	..	...	Loose
Safe	...	..	.	.	..	...	Dangerous
Ugly	...	..	.	.	..	...	Pretty
Weak	...	..	.	.	..	...	Strong
Old	...	..	.	.	..	...	New
Thin	...	..	.	.	..	...	Fat
Dry	...	..	.	.	..	...	Wet
Loud	...	..	.	.	..	...	Soft
Good	...	..	.	.	..	...	Bad
Little	...	..	.	.	..	...	Big

APPENDIX E

ATTITUDE OPINIONNAIRE

PRECEDING PAGE BLANK-NOT FILMED

ALLEN INVENTORY OF ATTITUDES TOWARDS SCIENCE AND SCIENTIFIC CAREERS

Instructions: Please give your reactions to the following list of statements regarding science, scientists, and scientific careers.
Work rapidly: Record your first impression -- the feeling that comes to mind as you read the item.

Draw a circle around AA if you completely agree with the item.
Draw a circle around A if you are in partial agreement.
Draw a circle around N if you are neutral.
Draw a circle around D if you partially disagree.
Draw a circle around DD if you totally disagree.

Example:

AA [✓ A] N D DD 100. In the springtime Paris is more beautiful than New York.

(Since A is circled, this indicates that you are in slight agreement.)

- - -

* AA A N D DD 1. Science is not sufficiently appreciated by most people.
* AA A N D DD 2. Science is a systematic way of thinking.
* AA A N D DD 3. Scientists are seldom concerned with their working conditions.
* AA A N D DD 4. The development of new ideas is the scientists's greatest source of satisfaction.

AA A N D DD 5. Friends often discourage girls from taking high school science courses.

* AA A N D DD 6. Science and technology are essential to the development of present-day cultures.

By special permission of The Science Manpower Project, Teachers College, Columbia University, and the author.

---

* The fifty-six items marked with an asterisk (*) are those that were included in the final analysis.

AA A N D DD 7. Increased radiation resulting from bomb tests is a threat to civilization.

* AA A N D DD 8. Scientists are too narrow in their views.

AA A N D DD 9. The President's cabinet should be enlarged to include a Secretary of Science.

AA A N D DD 10. Scientists and engineers should be eliminated from the military draft.

* AA A N D DD 11. The scientist will make his maximum contribution to society when he has freedom to work on problems which interest him.

AA A N D DD 12. A scientist might aptly be described as a non-conformist.

* AA A N D DD 13. Scientists should be looked upon as "subjects for suspicion."

AA A N D DD 14. Scientific investigations are undertaken as a means of achieving economic gains.

* AA A N D DD 15. To become a scientist requires superior ability.

* AA A N D DD 16. Science requires creative activity.

* AA A N D DD 17. Scientists are willing to change their ideas and beliefs when confronted by new evidence.

AA A N D DD 18. Scientists have unusually intelligent mothers.

* AA A N D DD 19. Scientists are "longhairs."

* AA A N D DD 20. Modern science is too complicated for the average citizen to understand and appreciate.

* AA A N D DD 21. Scientists possess too much power in our society.

* AA A N D DD 22. Decisive economic, political, and social processes are greatly influenced by science.

* AA A N D DD 23. It is undemocratic to favor exceptional scientific talent.

* AA A N D DD 24. The money awarded a Nobel Prize winner in Physics should be at least equal to that given popular entertainers.

AA A N D DD 25. Hazards created by the increased use of radioactive materials make scientific work less attractive than previously.

AA A N D DD 26. Scientists are shy, lonely individuals.

* AA A N D DD 27. Loyalty checks and security clearances have seriously interfered with the work of scientists.

* AA A N D DD 28. For me, training for a career in science is not worth the time and effort required.

* AA A N D DD 29. Science is primarily a method for inventing new devices.

* AA A N D DD 30. Scientists are more emotional than other people.

* AA A N D DD 31. Girls have very little mechanical aptitude and, therefore, should not consider scientific careers.

* AA A N D DD 32. Scientists are honored persons who stand very high in popular prestige.

* AA A N D DD 33. To appreciate modern society fully, a person must understand the importance of science.

* AA A N D DD 34. Scientists are an "odd" lot.

* AA A N D DD 35. Science without mathematics is impossible.

* AA A N D DD 36. Science is the greatest unifying force among nations.

* AA A N D DD 37. Maintenance of scientific work is essential to national survival.

* AA A N D DD 38. Scientific work is boring.

* AA A N D DD 39. The free flow of scientific information among scientists is essential to scientific progress.

AA A N D DD 40. Scientists display an almost irrational attachment to their work.

AA A N D DD 41. I don't have the intelligence for a successful scientific career.

AA A N D DD 42. The winning of the esteem of his associates is one of the main incentives for the scientist.

AA A N D DD 43. Scientific findings always lead to final truths.

AA A N D DD 44. The scientist can expect to accumulate little wealth as compensation for his work.

* AA A N D DD 45. Science is a man's world; there is little room in it for women.

* AA A N D DD 46. Science is primarily responsible for the frequent changes which occur in our manner of living.

AA A N D DD 47. Scientists are "eggheads."

* AA A N D DD 48. Scientific work requires long years of labor and self-discipline.

AA A N D DD 49. A great research scientist is little concerned with the practical applications of his work.

* AA A N D DD 50. Scientists are communistic.

* AA A N D DD 51. Science is an attitude towards life and environment.

AA A N D DD 52. Our foremost scientists are primarily concerned with their own thoughts and ideas.

* AA A N D DD 53. Science has done little for the average citizen.

* AA A N D DD 54. Scientific truths are usually found by persons seeking economic gain.

AA A N D DD 55. Scientists today are subject to too many governmental restrictions.

AA A N D DD 56. The engineer serves a more practical purpose in society than does the research scientist.

* AA A N D DD 57. There is much self-satisfaction to be received from work as a scientist.

* AA A N D DD 58. A scientist's life is full of adventure.

* AA A N D DD 59. The average American home discourages girls from scientific careers.

AA A N D DD 60. Universities do little scientific research that is of immediate practical value.

AA A N D DD 61. Scientists do not need the physical stamina necessary for most other work.

* AA A N D DD 62. Science helps us to understand our environment.

AA A N D DD 63. Scientists are against formal religion.

AA A N D DD 64. "Practical" politicians and businessmen disregard the advice of scientists.

* AA A N D DD 65. Scientists often have physical deformities which render them unfit for other work.

* AA A N D DD 66. Science and its inventions have caused more harm than good.

* AA A N D DD 67. The social environment of the United States is hostile to the development of scientific talent.

* AA A N D DD 68. One cannot have a normal family life and be a scientist.

* AA A N D DD 69. The bulk of scientific research is carried on by devoted men and women without regard for their personal living or social relations.

* AA A N D DD 70. Public interest in science is essential to the maintenance of scientific research.

AA A N D DD 71. Most of the basic scientific research done in our country is carried on by industry.

* AA A N D DD 72. Many specific findings in science contradict the laws of God.

AA A N D DD 73. American scientists are largely responsible for our country's status among nations.

* AA A N D DD 74. Scientists are essentially magicians, making two blades of grass grow where one grew before.

AA A N D DD 75. Industrial research is often carried on by teams of scientific workers.

* AA A N D DD 76. Scientific work is monotonous.

* AA A N D DD 77. The working scientist believes that nature is orderly rather than disorderly.

AA A N D DD 78. The modern world is dominated by science.

* AA A N D DD 79. Scientists as a group are often condemned for the unpopular ideas and activities of a few fellow workers.

AA A N D DD 80. Scientists are often willing to sacrifice the welfare of others to further their own interests.

AA A N D DD 81. Scientists are usually unsociable.

* AA A N D DD 82. Curiosity motivates scientists to make their discoveries.

* AA A N D DD 83. The chief reward in scientific work is the thrill of discovery.

* AA A N D DD 84. In high school, boys receive more encouragement to take science courses than do girls.

* AA A N D DD 85. Americans place greater value on the practical applications of scientific discoveries than on the discoveries themselves.

ATTITUDE OPINIONNAIRE

Subscore Categories

Category I. Science and Scientific Method

Items 2, 15, 16, 20, 28, 29, 31, 35, 38, 45, 48, 51, 74, 76, 77
Total 15 items

Category II. Scientist
Items 3, 4, 8, 17, 19, 30, 34, 50, 54, 57, 58, 65, 68, 69, 82, 83
Total 16 items

Category III. Society-Science Interrelations
Items 1, 6, 11, 13, 21, 22, 23, 24, 27, 32, 33, 36, 37, 39, 46, 53, 59, 62, 66, 67, 70, 72, 79, 84, 85
Total 25 items

Total number of items 56
Total possible score 56 x 5 = 280

APPENDIX F

STUDENT INFORMATION CARD

PRECEDING PAGE BLANK-NOT FILMED

STUDENT INFORMATION CARD

NAME: ____________________
(last name first)

PARENT'S NAME: ____________________

Address: ____________________

Phone: ____________________

Parent's Occupation:

____

College? ____________________

Vocation? ____________________

Circle one: M F

Period

Circle one: Jr. Sr.

Height: ____________________

Homeroom Teacher: ____________________

Room No.: ____________________

Seeing or Hearing Problems:

Side 1

GRADES			SCHEDULE		
Subject	Semester		Period	Subject	Room
	1	2			
Gen. Science 1,2			1		
Biology 1,2			2		
Biology 91,92			3		
Algebra 11,21			4		
Algebra 1,2			5		
Geom 11,21			6		
Geom 1,2			7		

Hobbies:

Extra Curricular Activities:

Side 2

APPENDIX G

TEACHER AND TEACHER ASSISTANT
TASKS, LOGS, CODES, SCHEDULES

PRECEDING PAGE BLANK- NOT FILMED

NDEA Physics Project

Task and Group Code

For teacher(s) using letter code throughout:

A - administrative ½:½
B - criterion based
C - voluntary

Group

A. whole class (W)
B. sub-group (S)
AB. approximately equal (½:½) division of whole class by sone criterion (AB)

Activities (tasks)

I. Instruction

1. Regular lecture-presentation-demonstration (LD)
2. Class discussion (disc)
3. Laboratory work - ½ class - administrative unit (lab_A)
4. Laboratory work
    - ½:½ criterion based (lab_{AB})
    - special interest group (lab_B)
    - voluntary (lab_C)
5. Differentiated instruction: extension of discussion from Group A - further refinement and development of concepts, etc., and/or their application to problems (S_+)
6. Differentiated instruction: extension of discussion from Group A -- advanced theory and problem work ($\overset{+}{S}$)
7. Differentiated instruction: remedial or review and amplification of discussion from Group A (S_o)
8. Shown materials - film, slide-tapes; include titles; if teacher, add "preview" if this describes your engagement (F,ST)
9. Quiz (Q)

II. Preparation

1. Generally, for class instruction; divide time between E and C if applicable. (Teacher assistant - laboratory work in E only) (PL)
2. Establishing criteria and procedures for evaluation - divide time between E and C if applicable (PG)
3. Evaluating student projects, notebooks, etc., E or C (G)
4. Marking tests - E or C - (Teacher assistant for E groups only) (GQ)
5. Establishing criteria and procedures in the management of class sub-groups - E only (PS)
6. Applying these criteria and forming the sub-groups - E only (S)
7. Logging time (log)
8. Quiz (PQ)
9. General overview of program (O)

Tasks to be assumed by the Teachers' Assistant

In general, she should be available to the teachers participating in the project for approximately 15 hours per week and assist them wherever non-professional activities are calculated to better serve the educational objectives of the experimental program. In discussing her role, we anticipated the following as representative of her activities:

(1) Maintaining in proper organization the variety of materials in the program -- films, slide-tapes, overlay transparencies, and printed materials such as reference readings, duplicated student handouts, scripts of the slide-tapes, etc.;
(2) Procuring the material, setting up the equipment, and projecting audio-visual media in formal classes and during "free access" periods;
(3) Supervising formal classes where the assistant is operating equipment in the projection of film and slide-tapes; (On these occasions, the teachers will have additional opportunity to plan and arrange for the daily implementation of the experimental program.) However, one of the two teachers ought to be readily accessible on these occasions for consultation;
(4) Logging "free access" instruction -- maintaining a complete record of the occasions on which students availed themselves of instruction via the media under her supervision;
(5) Providing clerical services to the teachers in the experimental program -- collating teacher logs recording the professional involvements of the teachers in both the experimental and control classes; marking objective tests for the teachers in experimental classes only; and performing the largely routine procedures in grouping students according to information on student cards or criteria decided upon by the teachers;
(6) Assist in preparation for laboratory sessions in the experimental classes only;
(7) Take attendance in both experimental classes. However, she should consult one of the two teachers when instances may involve the exercise of authoritative judgment.
(8) Supervising "free access" periods.

LOG OF TEACHER ASSISTANT

School ______________
Name ______________

Date: From__________to__________

Date	Class Period	Group A or B	Student(s) in B (names)	Nature of the Tasks (by Code)

APPENDIX H

PHYSICAL SCIENCE STUDY COMMITTEE FILMS USED IN PROJECT AND SLIDE-TAPE SERIES PREPARED FOR PROJECT

PRECEDING PAGE BLANK-NOT FILMED

Physical Science Study Committee
Physics Films Used in Project

No.	Title
0101	Time and Clocks
0119	Short Time Intervals
0102	Long Time Intervals
0103	Measuring Large Distances
0104	Measuring Short Distances
0105	Measurement
0106	Change of Scale
0107	Straight Line Kinematics
0108	Vectors
0110	Definite and Multiple Proportions
0113	Crystals
0115	Behavior of Gases
0201	Introduction to Optics (Color)
0202	Pressure of Light
0203	Speed of Light
0204	Simple Waves
0301	Forces
0302	Inertia
0304	Falling Bodies
0305	Deflecting Forces
0306	Periodic Motion
0307	Frames of Reference
0309	Universal Gravitation
0310	Elliptic Orbits
0311	Energy and Work
0312	Mechanical and Thermal Energy
0403	Coulomb's Law
0404	Millikan Experiment
0405	Coulomb's Force Constant
0406	Electric Fields
0408	Counting Electrical Charges in Motion
0409	Elementary Charges and Transfer of Kinetic Energy
0412	Electrons in a Uniform Magnetic Field
0413	Mass of the Electron
0415	Electromagnetic Spectrum
0418	Photons
0419	Interference of Photons
0421	The Franck-Hertz Experiment
0416	The Rutherford Atom

Slide-Tape Series Prepared for Project

No.	Title	No. of Slides	Running Time (Minutes)	Textbook Correlation Parts I-IV
1	Note Taking -- Helps and Ideas	60	27	General
2	Exponential Notation and Order of Magnitude	59	33	I
3	Measuring Frequencies with the Stroboscope	24	13	I
4	Measurement	35	20	I
5	Error and Accuracy	36	28	I
6	Significant Figures	29	30	I
7	Cosmic View	36	30	I
8	Techniques for Graphing Functional Relationships	27	12	I
9	Motion: Speed and Acceleration	28	30	I
10	Vectors	36	29	I
11	Molecular Layers	20	14	I
12	Trigonometric Functions	25	26	II
13	Interference	24	16	II
14	Introduction to the Film "Forces"	17	6	III

No.	Title	No. of Slides	Running Time (Minutes)	Textbook Correlation Parts I-IV
15	Simple Harmonic Motion	36	20	III
16	Potential (Gravity)	27	14	III
17	The Force Between Two Charged Spheres	34	14	IV
18	Electric Fields -- Point Charge	36	19	IV
19	Electric Fields -- Dipole	23	7	IV
20	Electric Fields -- Visualization	16	8	IV
21	Electric Fields -- Analogy and Summary	21	8	IV
22	Millikan Oil Drop Experiment	17	7	IV
23	Magnetic Fields	31	10	IV
24	Nuclear Reaction (Incomplete)			IV
25	Relativity I	31	22	IV
26	Relativity II	25	13	IV

PRECEDING PAGE BLANK-NOT FILMED

BIBLIOGRAPHY

1. Bloom, Benjamin S. (ed.) Taxonomy of Educational Objectives. New York: Longmans, Green, 1956.

2. Carpenter, C.R., Greenhill, L.P., and Others. An Investigation of Closed-Circuit Television for Teaching University Courses. Instructional Television Research Report No. 2. University Park, Pennsylvania: The Pennsylvania State University, Spring, 1958.

3. Commission on the Experimental Study of the Utilization of the Staff in the Secondary School. Exploring Improved Teaching Patterns -- Second Report on Staff Utilization Studies. Reprinted from The Bulletin of the National Association of Secondary School Principals, Vol. 43, January, 1959.

4. Finn, James D. "Automation and Education: III. Technology and the Instructional Process," Audio-Visual Communication Review, Vol. VIII, (Winter, 1960) 5-26.

5. Fritz, John O. "Educational Technology: A Way to its Assessment," Administrators Notebook, Vol. IX, No. 6 (February, 1961), Chicago: University of Chicago.

6. Fritz, John O. "Educational Technology -- Boon or Bane?", The School Review, Vol. 68 (Autumn, 1960), Chicago: University of Chicago, 294-307.

7. Greenhill, Leslie. "New Directions for Communication Research," Audio-Visual Communication Review, Vol. VII (Fall, 1959) 245-253.

8. Heidgerken, Loretta. "An Experimental Study to Measure the Contribution of Motion Pictures and Slide Films to Learning Certain Units in the Course Introduction to Nursing Arts," Journal of Experimental Education, 17 (December, 1948) 261-293.

9. Heller, Melvin P. and Belford, Elizabeth. Team Teaching and Staff Utilization in Ridgewood High School. Reprinted from The Bulletin of the National Association of Secondary School Principals, Vol. 46 (January, 1962).

10. Hoban, Charles F., Jr., and Van Omer, Edward B. Instructional Film Research 1918-1950, Technical Report No. SDC 269-7-19, Instructional Film Research Program, Pennsylvania State College, Port Washington, Long Island, N.Y.: Special Devices Center, December, 1950.

11. Johnston, Roland E., Jr. Magnetic Recordings and Visual Displays as Aids in Teaching Introductory Psychology to College Students. USOE Title VII Project No. 240, Drexel Institute of Technology, Philadelphia, May, 1961, 62 pp. Abstracted in AVCR, Vol. 9, No. 6, A46-47, November-December, 1961.

PRECEDING PAGE BLANK- NOT FILMED

12. Keeslar, Oreon. *Contribution of Instructional Films to the Teaching of High School Science.* University of Michigan, 1945.

13. Krech, David, and Crutchfield, Richard S. *Theory and Problems of Social Psychology.* New York: McGraw-Hill Book Co., Inc., 1948.

14. Meierhenry, Wesley C. *Enriching the Curriculum Through Motion Pictures.* Lincoln: University of Nebraska Press, 1952.

15. Morris, Charles. *Signs, Language, and Behavior.* New York: Prentice-Hall, Inc., 1946.

16. National Education Association. *Studies of the Utilization of Staff, Buildings, and Audio-Visual Aids in the Public Schools.* Research Report 1959-R17, Washington: Research Division, National Education Association, (October, 1959).

17. Popham, W. James, and Sadnavitch, Joseph M. *The Effectiveness of Filmed Science Courses in Public Secondary Schools.* USOE Title VII Project No. 091, Pittsburg: Kansas State College, August, 1960, 63 p.

18. Smith, Herbert A., and Washton, Nathan S. "Science in the Secondary Schools," *Review of Educational Research.* 27: (October, 1957), 343-355.

19. Tendam, D. J. *et al*. *Preparation and Evaluation in Use of a Series of Brief Films of Selected Demonstrations from the Introductory College Physics Course.* USOE Title VII Project No. 132, Purdue Research Foundation, Lafayette, Indiana, August 31, 1961, 45 p. Abstracted in *AVCR*, Vol. 10, No. 3, A98-99, May-June, 1962.

20. Thelen, Herbert A. *Teachability Grouping.* USOE Cooperative Research Project No. 428, University of Chicago, Illinois, August, 1961, 241. p.

21. University of Chicago Laboratory Schools. *An Informal Report on the Freshman Project 1961-62.* University of Chicago, Illinois, February, 1962, 18 p.

22. VanderMeer, Abram W. *Relative Effectiveness of Instruction by: Films Exclusively, Films Plus Study Guides, and Standard Lecture Methods.* Technical Report SDC 269-7-13, Instructional Film Research Program, Pennsylvania State College, Port Washington, Long Island, N. Y.: Special Devices Center, July, 1950.

23. *Wisconsin Physics Film Evaluation Project.* W. A. Wittich, Chairman. Madison: University of Wisconsin, 1959.